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NEWPORT LABORATORIES

Series AI Amplifiers

INSTRUCTION MANUAL

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Newport Laboratories, Inc., P. O. Box 2087, Newport Beach, Calif. 92663

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Appendix

Special Characteristics of Given Serial Nos.

Diagrams

PREFACE

The main body of this manual applies generally to all Series AI amplifiers. Information defining individual variants is provided in the appendix. Because of the numerous variations within Series AI, it is advisable to consult the appendix first and then study the rest of the manual in light of the particular configuration for which these manuals are furnished.

These are highly sensitive amplifiers for use in making very accurate measurements. To preserve data quality, the amplifiers must be properly understood and used, so a thorough study of this manual is essential to any user. Particular care should be devoted to grounding and shielding of the cables and other equipment used with the amplifiers.

Newport Laboratories

May, 1967

SERIES AI, DC AMPLIFIERS
TECHNICAL INFORMATION

Series AI amplifiers accept differential inputs from transducers or electrical equipment. They produce 10 volts full-scale, low-impedance outputs to equipment for digitizing and/or recording. Available gains range from 0.01 to 5000 and bandwidths from 1 Hz to 100 kHz. Differential input resistance is at least 20 megohms at gains of 1 or more. Common-mode rejection exceeds 123 db at 60 Hz, with gain = 1000 and 350 ohms unbalanced source. Because Series AI amplifiers are direct-coupled, they are free of chopper noise and intermodulation distortion and are not subject to the non-linearity of an open-loop isolater.

In relation to comparable amplifiers, Series AI provides the following advantages:

Simple circuit design yields reliability and low cost. Only 17 transistors are employed in the basic, differential amplifier A.

Full-scale response to 50 kHz without distortion.

Input impedance remains 20 megohms resistance shunted by 100 pf at all gains down to unity. When gain less than 10 or 20 is required, comparable amplifiers must sacrifice input impedance by employing an attenuator before the normal input.

Switchable, active filtering (1-pole or 2-pole) may be included in the differential preamplifier, amplifier A. Comparable amplifiers at increased cost and complexity must employ a separate, post-amplifier for bandwidth control.

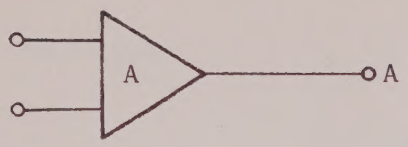
If a post-amplifier is added in the AI for active filtering, up to 4 poles (24 db/octave rolloff) may be obtained. Two poles may be included in the differential pre-amplifier, and/or two poles in the post-amplifier. All bandwidth control is ganged on a single switch, no matter where the filtering takes place.

Excellent rejection of high-frequency and transient common-mode voltages: e.g., 74 db CMR at 100 kHz and gain = 1000.

Numerous options, such as output commutation and a post-amplifier for galvanometer drive, provide the opportunity to select configurations specially suited to particular applications.

Optional galvanometer-driver controls are available to permit: (a) suppression of zero as much as 10 times full-scale, and (b) calibration of graphic recordings for direct results in units of the original parameter such as 10 psi or 10 $^{\circ}$C per chart division.

In the galvanometer driver, automatic current-limiting may be altered according to the galvanometer in use, giving foolproof protection against accidental destruction of galvanometers. Also, provision within the AI is made for mounting any damping and/or attenuating network a galvanometer may require.



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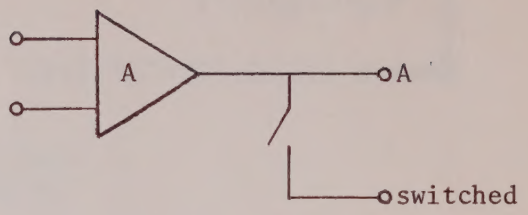

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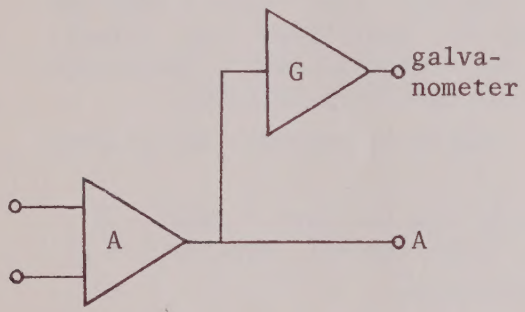

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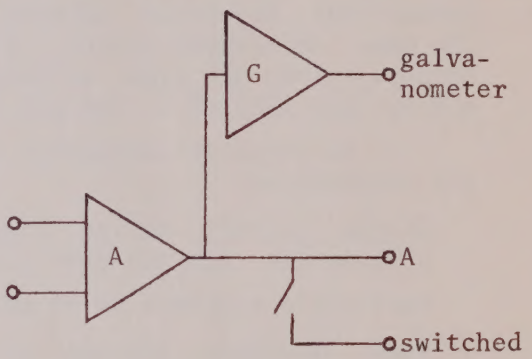

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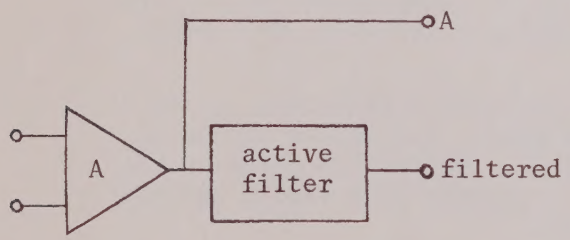

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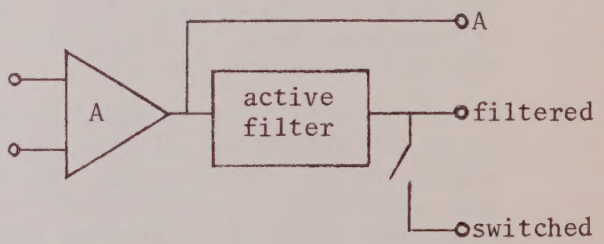

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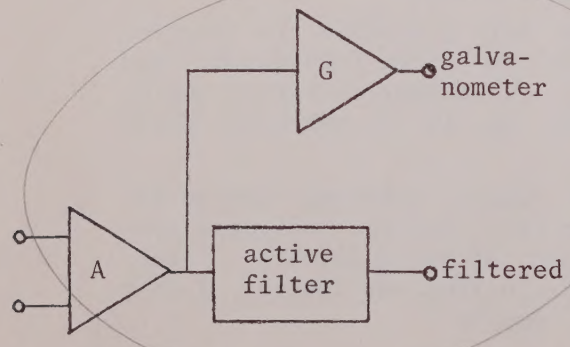

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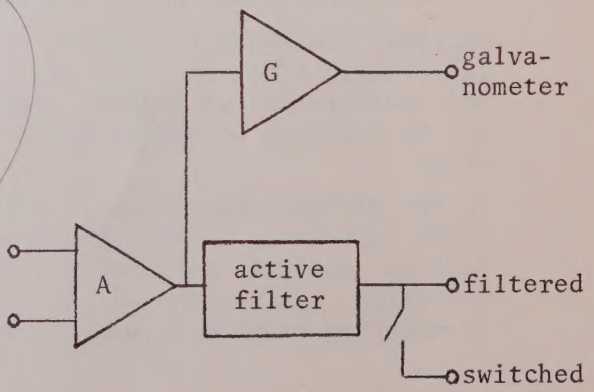


Configuration 8

On the opposite page are illustrated the amplifier configurations and output capabilities which are made possible by the optional output elements. For performance specification, the outputs are given the names: "A", "filtered", "switched" and "galvanometer". Performance specifications are given here for all options without necessarily defining how the options may be combined. For complete information on options, please refer to our separate publication, "Pricing and Ordering Information."

PERFORMANCE SPECIFICATIONS

guaranteed for all units at 25 °C after 30 minutes warmup

Definitions: %FS, percent of full scale
%R, percent of reading
RTI, referred to the input
RTO, referred to the output

DIFFERENTIAL INPUT

The input source may be either floating or grounded; no bias-current return path is required.

Impedance: 20 megohms resistance shunted by 100 picofarads

Full-Scale Differential Voltage: ±10 volts ÷ gain

Maximum Overvoltage Without Damage, on either input with respect to output ground

Without Fuses: ±25 volts peak
With Fuses: ±300 volts peak (fuse blows at 25 volts)

COMMON MODE

(Common-mode voltage is defined as the average of the voltages on the two signal inputs, with respect to output ground.)

Common-Mode Rejection at gain = 1000. CMR is proportional to the gain switch setting, so the error due to a given common-mode voltage remains a fixed %FS at all gain settings.

	0Ω source	350Ω unbalanced source	1KΩ unbalanced source
DC	126 db	125 db	123 db
60 Hz	126 db	123 db	120 db
400 Hz	122 db	117 db	112 db
1 kHz	114 db	110 db	104 db
10 kHz	94 db	90 db	84 db
100 kHz	74 db	70 db	64 db

Maximum Common-Mode Voltage for Linear Measurements: ±10 V peak

Maximum Common-Mode Voltage Without Damage
Without Fuses: ±25 volts peak
With Fuses: ±300 volts peak (fuse blows at 25 volts)

Capacitance from Input Guard Shield to Output Ground: 100 pf

Guarded Impedance from Either Signal Input to Output Ground:
5×10^9 ohms resistance shunted by 1 pf

GAIN (from differential input to any output except galvanometer)

Up to 11 switch settings, maintaining 20 MΩ input resistance

Minimum gain: 1
Maximum gain: 2000 standard; 5000 special

Error (with neither fine nor coarse adjustment) versus initial setting: ±0.01 %R for gains of 1000 or less;
±0.05 %R for gains up to 5000

or ±0.1 %R for all gains.

Error (without coarse adjustment) versus
Time: ±0.01 %R per month ±0.02 %R per 6 months
Temperature: ±0.002 %R per °C

Nonlinearity: ±0.01 %R for gains of 1000 or less
±0.05 %R for gains up to 5000

Fine Gain Adjustment (screwdriver)
Range: ±0.5 %R
Resolution: 0.001 %R

Coarse Gain Adjustment (screwdriver)

Range: increases gain as required (up to X 10) to cover the range between switch steps

Resolution: 0.5 %R

Stability versus
Time: ±0.5 %R per month ±1 %R per 6 months
Temperature: ±0.02 %R per °C

Adjustment Bypass, 3-position switch:

1. Gain steps calibrated as indicated on the gain switch -- coarse and fine adjustments inoperative
2. Fine adjustment operative, but not coarse
3. Both coarse and fine adjustments operative

INPUT ATTENUATOR

When the attenuator is switched in, it divides both the differential-mode and the common-mode input.

Input Resistance: 1 MΩ either input to output common;
2 MΩ differential

Attenuation Factor: 0.01

Maximum Common-Mode Voltage for Linear Measurements: ±300 V peak

Common-Mode Rejection, DC to 60 Hz: 60 db standard;
80 db special

Frequency Response: ±3 db to 20 kHz

DYNAMIC RESPONSE

Small-Signal Bandwidth (-3 db corner frequency, low pass)

Maximum: 100 kHz
Minimum: 10 Hz standard; 1 Hz special

Bandwidth Control Switch

Number of positions: up to 9

Bandwidth limiting takes place:

(a) 1 or 2 poles in amplifier A, or

(b) 2 poles in the active filter, or

(c) 2 poles in amplifier A plus 2 poles in the active filter, totaling 4 poles.

Response Shape: 2-pole or 4-pole with Bessel, Butterworth or special characteristics; or 1 pole.

Effect of Coarse Gain Adjustment: If the coarse gain adjustment is used to increase gain by a factor of 10, maximum bandwidth becomes 30 kHz, for gain switch settings of 1000 or less.

Effect of Very Large Gain: Maximum bandwidth is reduced in proportion to the increase of switched gain above 1000. If the gain switch is set at 5000, maximum bandwidth is 20 kHz. If the coarse gain adjustment is used at the same time to increase gain to 50,000, maximum bandwidth is 15 kHz.

Slewing Limit

RTO: 3.1 volts per microsecond (full-scale sinusoidal response undistorted to 50 kHz; ±5 V peak sinusoidal response undistorted to 100 kHz)

RTI: 1 volt per microsecond, limits full-scale response only at gains less than 3.

Settling Time in response to a 10-volt RTO full-scale step, with 100-kHz, 1-pole bandwidth

To within 0.1% residual error at switched gain settings up to 1000: 15 microseconds

To within 0.01% residual error

Switched gain = 1: 70 microseconds

Switched gain = 2: 50 microseconds

Switched gain = 5 to 1000: 25 microseconds

ZERO OFFSET (RTI of amplifier A, RTO for any output) versus

Initial Setting: (±1.0 μv ± 1 na) RTI ±0.5 mv RTO

Time: {(±2 μv ± 1 na) RTI ± 0.2 mv RTO} per day
{(±10 μv ± 2 na) RTI ± 0.5 mv RTO} per month

Temperature: {(±0.5 μv ± 1 na) RTI ± 0.2 mv RTO} per °C

Power Supply: {(±0.2 μv ± 0.2 na) RTI ± 0.5 mv RTO} per % change in DC supply. No sensitivity to ±10% line variation when a Newport Laboratories DC supply is used.

Effect of Coarse Gain Adjustment: All RTO offset errors are multiplied by the gain attributable to the coarse gain adjustment.

AC NOISE with 1 kilohm source impedance
(RTI of amplifier A, RTO for any output. Noise from DC to 0.1 Hz is considered zero offset drift.)

0.1 Hz to 10 Hz: 1 μv RTI and 0.5 mv RTO, peak 99.9% confidence
0.1 Hz to 100 Hz: 2 μv RTI and 1 mv RTO, peak 99.9% confidence
0.1 Hz to 1 kHz: 1 μv RTI and 0.5 mv RTO, rms
0.1 Hz to 10 kHz: 3 μv RTI and 1.0 mv RTO, rms
0.1 Hz to 100 kHz: 10 μv RTI and 2.0 mv RTO, rms

Effect of Coarse Gain Adjustment: All RTO noise errors are multiplied by the gain attributable to the coarse gain adjustment.

GALVANOMETER DRIVER

Input

Voltage: ±10 volts full scale from Amplifier A
Impedance: 10 kilohms

Controls

Gain Adjustment (screwdriver)

Range	0.1 to 10	0.1 to 1	1 to 10
Resolution	(0.2 ÷ gain) %R	(0.02 ÷ gain) %R	(0.2 ÷ gain) %R

Offset Adjustment (screwdriver)

Range: ±10 volts, referred to galvanometer driver input

Resolution: 5 millivolts

Stability versus
Time: ±10 mv per day ±25 mv per week
Temperature: ±5 mv per °C

Calibration, 6-position switch

1. Normal data input is measured.
2. Normal data input is disconnected, so output goes to zero or to offset determined by offset adjustment.
3. through 6. ±10 v or ±1 v calibration signal is added to the normal data input.

Calibration Error versus

Initial Setting: ±0.2 %R

Time: ±0.1 %R per day
±0.25 %R per week

Temperature: ±0.05 %R per °C

OUTPUT CHARACTERISTICS

Impedance: 0.1 ohm in series with 50 microhenries, all outputs except switched output

Voltage: ±10 volts full scale, all outputs

Rated Current

Output A: 10 ma standard; 100 ma available if not required from the galvanometer driver

Galvanometer: 100 ma maximum; current limiting may be changed by the user to some lower value for galvanometer protection

Filtered: 10 ma

Protection: short-circuit current is limited safely, all outputs

Capacitive Load: no instability with up to 1 microfarad on each of the three amplifiers

SWITCHED OUTPUT

This output is formed by switching either the amplifier A output or the filtered output; so, with the exception of output impedance, this output has the same specifications as the output from which it is formed. The switching device is a silicon field-effect transistor.

Impedance

Switch On: 250 ohms in series with 50 microhenries

Switch Off: 10^9 ohms in parallel with 5 picofarads

Switch Drive

A two-input AND gate is provided so the amplifiers may be wired in a two-dimensional address matrix.

Control Levels: +2v or more turns the switch on (+18v maximum)

+1v or less turns the switch off

Delay: 1 microsecond

MANUAL CALIBRATION SWITCHING

In the bandwidth switch, two of its positions are employed to disconnect the signal source and: (1) short the amplifier A input, or (2) connect amplifier A's input to an external, calibration source.

AUTOMATIC CALIBRATION SWITCHING

A circuit can be included to allow automatic switching of the amplifier A input to an external, calibration source. Control levels are ground and positive, compatible with integrated circuits.

DC POWER REQUIREMENTS

These single-channel power requirements apply if the user elects not to purchase power supplies from Newport Laboratories.

Voltage: plus and minus 25 volts

Current: 40 ma from each supply, plus output loads, plus current from each supply to power the selected options as follows:

Galvanometer Driver: 20 ma
Active Filter: 20 ma
Commutator Switch: 5 ma
Automatic Calibration Switch: 1 ma

AC POWER REQUIREMENTS for power supplies furnished by Newport Laboratories

Voltage: 115 or 220 volts ±10%, RMS sinusoidal

Frequency: 50 to 60 hertz

RMS Current:

	115 volts	220 volts
single-channel supply	80 ma	40 ma
10-channel supply	800 ma	400 ma

TEMPERATURE RANGE

Operating: 0°C to +55°C
Storage: -25°C to +71°C

PACKAGING

Up to ten amplifiers fit in one holder 3½ inches high, for mounting in a RETMA 19-inch relay rack. The holder is of open-frame construction, allowing free passage of cooling air between circuit cards. The rack-mounting holder may include a 10-channel power supply, or each amplifier may contain an integral power supply.

Single-amplifier cases also are available, to contain one amplifier with integral power supply.

SECTION 3

UNPACKING & INITIAL INSPECTION

Before it is opened, the shipping container should be inspected for damage or evidence of abuse. After the container is opened and the presence of all expected material is verified, each amplifier should be inspected for shipping damage in accordance with the checklist below. If any apparent damage is found, the carrier should be notified immediately to establish a record of suspected shipping damage in case an insurance claim should become necessary.

1. Manipulate the knobs and the handle on the front panel to be sure they are intact and properly tightened. If they are merely loosened, they may be re-tightened with a screwdriver or allen wrench. If knobs have been misaligned relative to the panel markings, they may be re-aligned after the switch is turned to a stop at either extreme.

2. Verify that adjustment potentiometers are aligned so they are accessible through the screwdriver holes in the front panel.

3. Manipulate the front panel and the fiberglass-epoxy cards to ascertain that all screws are securely fastened.

4. Manipulate the power transformer to ascertain that it is securely mounted to the circuit card.

5. Gently manipulate the shield covers and switch brackets to determine that they are securely fastened.

6. Visually inspect the entire unit for dents, abrasion, corrosion, broken parts, cracked solder joints or de-lamination of the printed circuit.

SECTION 4

PRECAUTIONS

Series AI amplifiers are system components designed for use by technically skilled personnel. As such, they are vulnerable to abuses and oversights which are itemized here to the extent they can be foreseen.

DOs

Be sure the connector is clean, free of corrosion and properly wired. In particular, before power is applied, be sure DC power is wired with correct polarity in the case of amplifiers not containing integral power supplies.

When using a non-polarized connector for bench tests, be sure the connector is oriented correctly. Reversal of the connector end-for-end may cause damage by application of power to the signal input.

Be sure to connect properly the shield between windings of the power transformer. (See page 18.)

Be sure the shield of the input cable is connected both at the amplifier and at the signal source.

Be sure rack-mounting holders are installed right-side up. Pin 1 of the printed-circuit edge connectors should be on top.

Allow 15 to 30 minutes warmup time after power is turned on, before the amplifiers are calibrated or adjusted for zero offset.

Be sure to set the gain switch for maximum gain while the input offset is being adjusted to zero.

In driving a galvanometer, be sure the value at which output current is automatically limited by the amplifier is appropriate to the galvanometer in use.

DON'Ts

For differential amplifiers, don't connect the input guard shield to local ground or output ground at the amplifier.

Don't operate in fields of great magnetic flux, such as near large, electric motors or generators.

Don't operate the amplifiers in an environment where other equipment generates much heat.

Avoid using a fan or otherwise subjecting the amplifiers to turbulent air currents. Natural convection suffices to cool the amplifiers, if vertical air flow is unimpeded and no heat generators are enclosed in the same space.

Don't attempt to force switches past stops.

Don't clean switch wafers with trichloroethylene or any hydrocarbon solvent which attacks the plastic, switch parts. Use isopropyl alcohol only.

Don't clean switch wafers without afterward re-lubricating the contact surfaces with a heavy, silicone oil.

Don't exceed voltage ratings on the signal input or power supply.

Don't measure an input-protection fuse with an ohmmeter, except on the high-resistance scale. The current generated by an ohmmeter on a low-resistance scale is sufficient to blow the 10 ma input fuse.

Don't readjust potentiometers other than those accessible via front panel holes.

Don't lay the amplifier on a conductive or dirty surface for checkout.

Don't subject to abrasion the wiring side of the printed-circuit card.

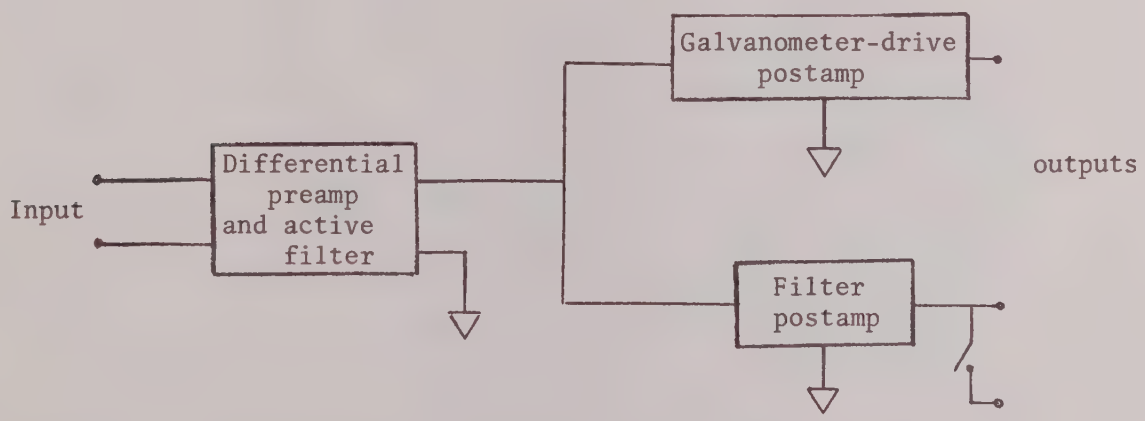
SECTION 5

BLOCK DIAGRAM

EXPLANATION OF OPTIONS

A complete description of the options available in Series AI amplifiers is given by the performance specifications and the pricing form. The purpose of this section is to present a block diagram of the amplifier as a basis for understanding the options which may be included.

A single, Series AI amplifier package may contain as many as three, elemental amplifiers: a differential pre-amplifier followed by two, single-ended post-amplifiers.



With a solid-state switch located as shown, as many as three different kinds of output may be simultaneously available.

Any of the three, elemental amplifiers may be omitted for the purpose of a particular application, but the signal paths indicated in the diagram may be maintained by jumpering through the unused sections. The output switch is similarly optional.

An output stage of 100 ma capability is standard in the galvanometer driver. If the galvanometer driver is not included, the 100 ma stage may be used as the output stage of the differential

preamplifier. There is only one, 100 ma output stage in the AI package, so only one output may have this capability.

It is important to note that the filter postamp is not the only way of controlling bandwidth, because switchable filtering may be included as part of the differential preamp. If 6 db/octave or 12 db/octave filtering in the differential preamp is satisfactory, then a filter postamp is not required. The filter postamp contributes attenuation of 12 db/octave; so, if 12 db/octave filtering is included in the differential preamp as well as in the filter postamp, a total rolloff rate of 24 db/octave may be obtained at the output of the active filter. Bandwidth control is ganged on a single, rotary switch no matter in which amplifier(s) the filtering takes place.

If filtering is included in the differential preamplifier, of course the bandwidth of subsequent outputs is limited accordingly. If 24 db/octave rolloff is provided using both the preamp and the postamp as filters, filter mathematics dictate that the optimum response characteristic (Butterworth, Bessel, etc.) is obtained only at the ultimate output from the filter postamp. The bandwidth of the preamp output in this case may differ from the bandwidth of the filter postamp by a factor of about 1.5.

The function of common-mode rejection and the principal amplifier gain controls reside in the differential preamplifier. If an input attenuator is included, it is located before the input to the differential preamp.

For the purpose of scaling graphs in convenient units and/or suppressing offset, a self-contained calibrator and continuously-adjustable controls for offset and gain may be included in the galvanometer driver.

SECTION 6

ELECTRICAL CONNECTIONS

Most connections to the amplifier are made by means of the 15-pin, printed-circuit edge connector, via the quick-disconnect connector panel if the connector panel option is included. In addition, there are a few parts for selection by the user which mount on the circuit card on solder terminals. Since connections depend partly on the options included, connection information peculiar to individual orders is provided in the appendix to this manual.

The general wiring list for the 15-pin edge connector is as follows:

1 - AC or plus DC power
2 - AC or minus DC power
3 - Power transformer shield
4 - Commutator address
5 - Commutator address
6 - 10 ma continuous output from preamp, or 100 ma output
7 - Switched output
8 - Continuous, 10 ma output
9 - Output ground
10 - Calibrate address
11 - Calibrate input signal
12 - Calibrate ground
13 - Input guard shield
14 - Non-inverting data input
15 - Inverting data input

When the amplifier card is viewed from the component side with the silkscreened part no. and model no. properly oriented for normal reading, the connector end of the card is at the right hand. In this attitude, contact No. 1 is at the top of the card and contact No. 15 is at the bottom.

If the amplifier contains its own DC power supply, contacts 1 and 2 are used for AC power and contact 3 is the electrostatic shield between primary and secondary of the power transformer. DC power is routed through contacts 1 and 2 and contact 3 is unused, if the amplifier does not contain its own DC power supply.

The power transformer shield should be connected in the grounding system at the point where it is most effective in preventing error due to ground loop current. If the system contains a central ground node to which separate ground conductors are returned from all components, this central node is a good place to connect the power transformer shield. Another suitable point to connect the power transformer shield might be AC power ground, provided that AC power ground is connected by some route to signal ground at the amplifier output and does not stand at a large common-mode voltage with respect to signal ground at the amplifier output. In prewired, rack-mounting holders for AI amplifiers, the power transformer shields are connected to the ground pin of the three-wire AC power cord to facilitate connection of these shields to AC power ground. The ground wire of the AC power cord must be removed from the shield terminal if some other disposition of the shields is to be made.

Contacts 4 and 5 AND logically two digital signals to turn on the output commutator switch in amplifiers containing this option. Please refer to the performance specifications in Section 1 of this manual and to the schematic diagram for details of this interface. If digital signal is applied to only one of these two contacts because the AND logic is not desired, the unused contact must be grounded.

If a galvanometer-driver post-amplifier is included, its output is on contact 6. Or, if there is no galvanometer-driver but 100 ma output capability is provided from the differential preamplifier, the preamp output in this case is on contact 6. Even if the preamp output capability is only 10 ma, the preamp output is on contact 6 in amplifiers including an active filter but no galvanometer driver, because the other 10 ma output contact (no. 8) is pre-empted by the active filter.

If a commutator switch is included, the switched output is on contact 7.

If an active filter is included, the continuous (unswitched), filtered output is on contact 8. If there is no active filter but a 10 ma output is available from the differential preamplifier, the preamp output in this case is on contact 8.

For wiring of signal outputs (contacts 6, 7 and 8), the best type of cable is single-conductor with a coaxial shield connected to ground. Characteristic impedance is unimportant and RG/U cable is not needed. Alpha Wire No. 2254/1 is recommended.

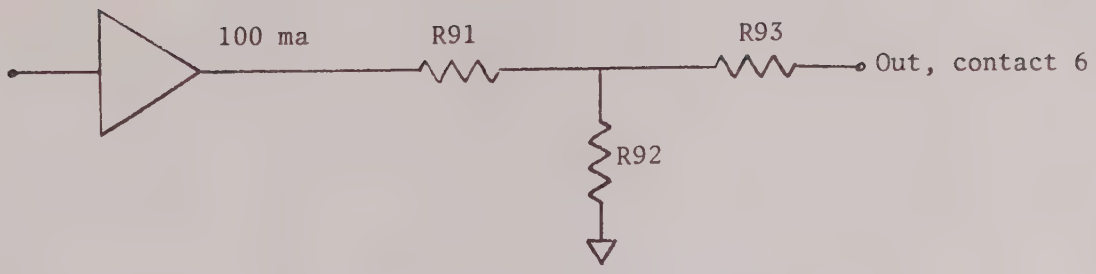
Contact 9 should be connected to the central ground node of the analog system. In general, in the ground structure of an analog measuring system, long ground busses should be avoided and separate ground returns from each component to a central node should be used instead.

In amplifiers which include automatic calibration switching, a digital signal applied to contact 10 determines whether test data or the calibration voltage is measured. Please refer to the performance specifications in Section 1 of this manual and to the schematic diagram for details of this interface.

Contacts 11 and 12 receive the calibration voltage, in amplifiers which include either manual or automatic calibration switching. The calibration voltage source should have an output impedance low enough to prevent any difficulty with electrostatic pickup, and negligible common-mode voltage with respect to amplifier output ground. Under these conditions, the principal problem in transmitting the calibration signal is electromagnetic (inductive) pickup; so single-conductor cable with a coaxial shield should be used. The shield should be grounded at the calibration voltage supply, and connected at the other end to contact 12. Alpha Wire No. 2254/1 is recommended for transmitting the calibration signal.

Contacts 13, 14 and 15 receive the test data signal. The output of the differential preamp is in-phase with reference to contact 14 and at 180° phase with reference to contact 15. (Depending on the options included, the post-amplifiers may or may not invert the signal, so the various outputs sometimes are out-of-phase with one another.) To minimize electrostatic pickup and common-mode error, the input cable should have a foil shield to provide 100% shield coverage and a drain wire to reduce shield resistance. To minimize electromagnetic (inductive) pickup, the two input signal wires should be twisted as tightly as possible. Belden 8451 cable is recommended.

In addition to the connections on the printed-circuit edge connector, there are in the 100 ma output circuit several resistors which may be selected by the user for current limiting or galvanometer damping. The resistors for the damping network are selected according to instructions of the galvanometer manufacturer and installed on solder terminals in the network:



Series AI amplifiers normally are supplied from the factory with jumpers in the R91, R93 positions and with R92 open.

R89 and R90 are the resistors which may be selected to control the automatic limiting of short-circuit current I_{ss} in the "100 ma" output. Letting R89 = R90 = R, the required resistance value may be calculated as follows to produce the I_{ss} limit desired:

$$R = \frac{1230 \text{ mv}}{I_{ss}}$$

With R known, the maximum output current for linear signal, I_1, may be calculated:

$$I_1 = \frac{820 \text{ mv}}{R}$$

SECTION 7

CONTROLS

Since almost all the controls on AI amplifiers are optional, some of the controls described below will be absent from some units. (See the description of options in Section 5 of this manual.) The reader needs give attention only to the description of those controls actually present in his units. All controls are located on the front panel. When studying this part of the manual, the reader will find it helpful to have an amplifier physically before him.

Preamp Gain Controls

The upper portion of the front panel contains the controls related to the gain of the differential preamplifier. These are (1) gain selector switch, (2) gain adjustment bypass switch, (3) fine gain adjustment potentiometer, and (4) coarse gain adjustment potentiometer. Since these controls operate on the differential pre-amplifier, they affect all outputs.

The gain selector switch is the outer, larger knob of the upper, concentric pair. If there is no gain adjustment bypass switch, then the gain selector switch is the only knob in the upper portion of the panel. The gain or sensitivity selected is read in the window above the knob.

The gain adjustment bypass switch is the inner, smaller knob of the upper, concentric pair. This switch controls the use of the continuous gain adjustment potentiometer(s). When the indicator of the gain adjustment bypass switch points at the window which displays the setting of the gain selector switch, then gain is calibrated at the value in the window and the gain adjustment potentiometer(s) is (are) inoperative. When the gain adjustment bypass switch is turned to indicate one or both of the gain adjustment potentiometers, then the indicated potentiometer(s) is (are) operative and

gain is uncalibrated. When gain is uncalibrated, the value appearing in the window is not necessarily valid.

There may be one or two potentiometers for coarse gain adjustment, fine gain adjustment or both. When there are two potentiometers, they are labelled respectively COARSE and FINE. If there is only one gain adjustment potentiometer, it may be labelled simply ADJUST without indication as to whether it is a coarse or fine adjustment.

If the fine gain adjustment potentiometer is indicated by the gain adjustment bypass switch, then this potentiometer may be used to adjust the gain through a range of ±0.5% with resolution better than 0.005%.

If the coarse gain adjustment potentiometer is indicated by the gain adjustment bypass switch, then this potentiometer may be used to increase gain above the value displayed in the window by the gain selector switch. The available range of gain adjustment is sufficient to cover fully the region between the steps of the gain selector switch. The resolution of the coarse gain adjustment is better than 0.5%.

Galvamp Controls

The middle portion of the panel is devoted to control of the galvanometer driver postamplifier. These controls are: (1) GAIN potentiometer, (2) OFFSET potentiometer, and (3) calibration switch -- the inner, smaller knob of the lower, concentric pair. The abbreviation "FS" on the calibration switch signifies full scale. These three controls operate on the galvanometer driver amplifier and affect its output only.

The GAIN potentiometer adjusts gain of the galvanometer driver over the range stipulated at the time the amplifiers

were ordered. Standard, optional gain ranges are: X0.1 to X1, X0.1 to X10, or X1 to X10. The uses of the GAIN adjustment are: (1) to scale graphic recordings in units of the original parameter, such as 10 psi or 10°C per chart division, and/or (2) to amplify a small AC component after the OFFSET potentiometer has been used to suppress a large zero offset. To scale a graph, the gain adjustment is made to obtain the proper deflection when ±0.1 FS or ±FS signal is switched in with the calibration switch.

The OFFSET potentiometer operates on the input to the galvanometer driver and has a range of ± full scale (±10 volts) at this point. If recording of the data relative to zero voltage is desired, the OFFSET potentiometer should be adjusted with the calibration switch in the ZERO position, to establish at a convenient position on the graph the level which corresponds to zero data voltage. Alternatively, if zero data voltage is not desired as a reference but instead the offset of the data is to be suppressed, the OFFSET potentiometer should be adjusted with the calibration switch in the DATA position to establish the offset of the data at a convenient position on the graph.

The galvanometer calibration switch is the inner, smaller knob of the lower, concentric pair. If there is no bandwidth switch, then the calibration switch is the only knob in the lower position. The DATA position is the normal position of this switch for data measurement and recording. In the ZERO position, the data input is disconnected from the galvanometer driver and its output goes to zero or to whatever "zero" reference is established by the OFFSET potentiometer. In the four positions labeled ±0.1 FS and ± FS, a calibration signal of the indicated magnitude and polarity is superimposed on (added to) the data and offset inputs. (The abbreviation "FS" signifies full scale magnitude, referred to the input of the galvanometer driver.)

Bandwidth and Input Calibration Controls

The lower portion of the panel contains two controls: (1) a zero potentiometer to compensate for long-term drift at the input of the differential preamplifier, and (2) a switch used primarily for bandwidth control, but with two positions reserved for manual calibration.

The bandwidth/calibration switch knob is the outer, larger knob of the lower, concentric pair. If there is no galvanometer calibration switch, then this switch is the only knob in the lower position. Most of this switch, starting from the maximum clockwise position, is devoted to bandwidth control. The value of the selected bandwidth, in hertz, appears in the window below the knob. Bandwidth is indicated in terms of the -3 db corner frequency, unless some other bandwidth criterion was specified by the customer in the purchase contract. Depending on how the amplifiers were ordered, the bandwidth control may operate on the differential preamplifier and/or the active filter postamplifier in any of the following ways:

1. There may be no active filter postamplifier, in which case the bandwidth control operates only on the differential preamplifier, and all outputs are bandwidth-limited at the same frequency.

2. The bandwidth control may operate on the active filter postamplifier only, in which case the outputs from the galvanometer driver and directly from the differential preamplifier remain wideband regardless of the bandwidth switch setting.

3. The bandwidth control may operate on both the differential preamplifier and the active filter postamplifier. In this case, the output from the active filter postamplifier rolls off at 24

db/octave, while outputs from the galvanometer driver and directly from the differential preamplifier roll off at 12 db/octave. The cutoff frequency of all outputs is controlled by the bandwidth switch. The filter mechanism consists of a 2-pole section in the differential preamplifier and another 2-pole section in the active filter postamplifier. Therefore, the explicit specifications on frequency response shape (Bessel, Butterworth, etc.) and location of the cutoff frequency apply only to the 24 db/octave output, and corresponding parameters for the 12 db/octave outputs are determined implicitly by filter mathematics.

The two positions at the extreme counter-clockwise position of the bandwidth/calibration switch are employed for calibration. The panel and dial markings relating to calibration functions appear in script lettering. When "zero" appears in the window, the input to the differential preamplifier is disconnected from the data source and a short is placed across it. When "ext" appears in the window, the input to the differential preamplifier is disconnected from the data source (contacts 14 and 15) and connected instead to contacts 11 and 12, where an external calibration voltage may be connected. In the "ext" and "zero" positions of the bandwidth/calibration switch, the bandwidth of the amplifier is at its minimum value. Some amplifiers are supplied with just a single calibration position on this switch, either "ext" or "zero", or with no calibration switching.

It is important to recognize that the function of the bandwidth/calibration switch when it is in the calibration positions (extreme counter-clockwise) is entirely different from its function when it is in one of the bandwidth positions.

The "zero" potentiometer is used to compensate for the effect of long-term drift at the input to the differential preamplifier. The end-to-end adjustment range of this potentiometer is 500 microvolts. While zero is being adjusted, a short circuit should be placed across the amplifier input. The preamp gain should be set at its maximum value to obtain the best possible resolution in setting zero; then the zero reference will remain the same at all values of gain.

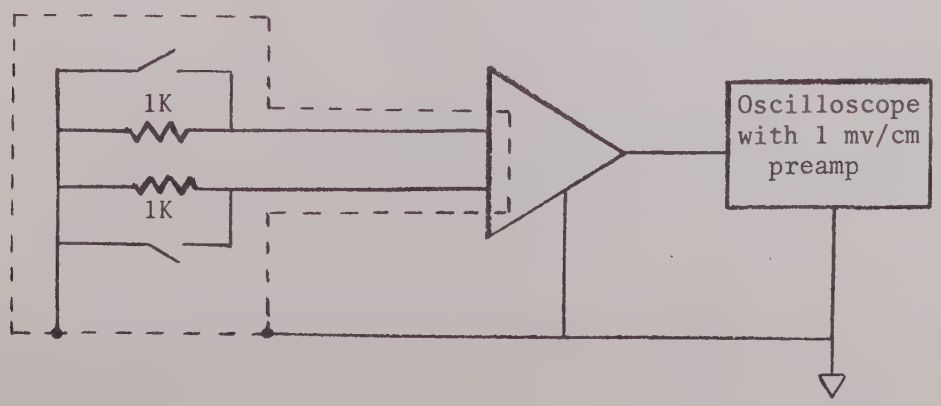
SECTION 8

PERFORMANCE TESTING

Electrical performance of AI amplifiers may be tested according to the procedures explained in this section. The complete tests described here are more exhaustive than necessary for the checking of new amplifiers for shipping damage. As an abbreviated test for this purpose, checking of the following parameters is recommended before the amplifiers are put into service: (1) noise and offset at maximum gain, with shorted input, (2) common-mode rejection at any frequency of interest, with shorted input and maximum gain, and (3) -3 db frequency at minimum gain, using about 1 volt peak-to-peak signal referred to the amplifier output. These three tests are recommended because they are easy to set up and may be conducted without any shielding of the input leads. However, this manual should be read thoroughly before the amplifiers are operated at all, with particular attention to the detailed test instructions below relating to any simplified test that is contemplated.

For tests involving low-level signals and/or large source impedances, proper shielding of the test circuits and input leads is vital. Not only should the input cable be shielded, but the signal leads should be tightly twisted as well. A suggested shield structure is indicated by dashed lines in the test circuits described below. A further caution should be observed with respect to ground loops in the test setup.

Noise and Drift



Input errors are measured with maximum gain in the amplifier, since they overshadow the output errors at maximum gain. (Maximum gain in most AI's is about 1000.) Output errors are measured with minimum gain in the amplifier, since input errors at minimum gain have negligible effect on the output. (Minimum gain in most AI's is unity.) With zero resistance in the input circuit, the input errors measured are voltage offset and voltage noise. When 1K is placed in the input circuit, the increase in error is due to input current offset and input current noise. It is useful to place resistance in just one input at a time, since current offsets may tend to cancel one another if the source resistance is balanced. The effects of various noise sources accumulate as the square root of the sum of the squares of the RMS values, since all noise sources normally are gaussian.

Since noise values may be expressed in different ways, conversion factors must be kept in mind. The peak value obviously is one-half of the peak-to-peak value. The peak/RMS ratio depends on the required confidence that the stated peak value will not be exceeded, as follows:

% of time the peak is exceeded	10%	1%	0.1%	0.01%	0.001%
Peak/RMS ratio	1.645	2.576	3.291	3.890	4.417

An instrument which determines the average, rectified value of an AC signal may be used to measure noise; and the readings may be converted to RMS values for gaussian waveform by the form factor:

$$\frac{\text{RMS value}}{\text{average, rectified value}} = 1.253$$

The form factor for a sine wave is 1.111, and many AC meters which measure the average, rectified value of a signal are calibrated to indicate readings of sinusoids on an RMS scale. Such

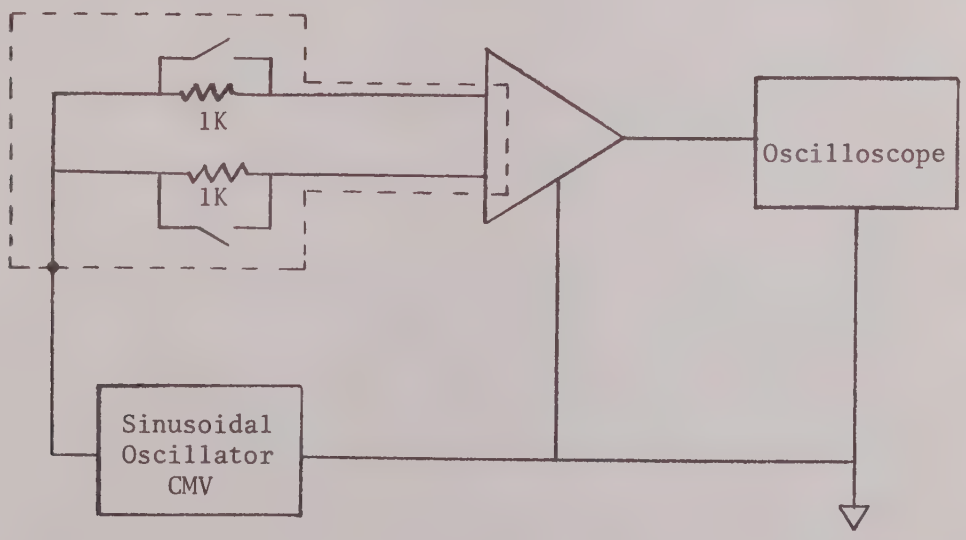
meters may be used to measure gaussian noise if the readings are converted for the change in waveform by the factor:

$$\frac{\text{RMS value of gaussian waveform}}{\text{AC meter reading}} = \frac{1.253}{1.111} = 1.128$$

The foregoing conversion factors are taken from Bennett, W. R., "Electrical Noise," pg. 44, McGraw-Hill, 1960.

Input voltage offset may be adjusted to zero by means of the screwdriver potentiometer at the bottom of the front panel. Output offset and input current offset are adjusted to near-zero at the factory and normally need not be readjusted in the field. Input noise at various bandwidths may be measured by operating the bandwidth switch, if the amplifier includes a bandwidth switch. Noise normally increases approximately in proportion to the square root of bandwidth, except at low frequencies where 1/f noise may predominate.

Common-Mode Rejection



With 20 volts p-p common-mode voltage applied,

$$\text{Common-mode rejection} = \frac{20\ A}{V_{out}}$$

A = differential amplifier gain

V_{out} = peak-to-peak voltage at the common-mode frequency, read on the oscilloscope in volts.

20 volts p-p common-mode voltage (CMV) is suggested because this is the maximum CMV for which the rejection ratio remains high. The CMV must vary symmetrically around zero, of course, so the peaks do not exceed ± 10 volts. The oscilloscope should have a sensitivity of 10 mv/cm or better. The bandwidth of the amplifier should be at least 2.5 times greater than the common-mode frequency generated by the oscillator.

The common-mode rejection (CMR) ratio is highest at the highest value of differential gain. CMR is specified at gain = 1000, and it is convenient to perform the measurements at this gain setting. Spot checks at lower gains may be performed quickly by switching down the gain and observing that the output error due to CMV, as displayed on the oscilloscope, remains approximately constant or decreases slightly. This indicates that CMR is proportional to gain and, therefore, output error due to a given CMV is independent of gain.

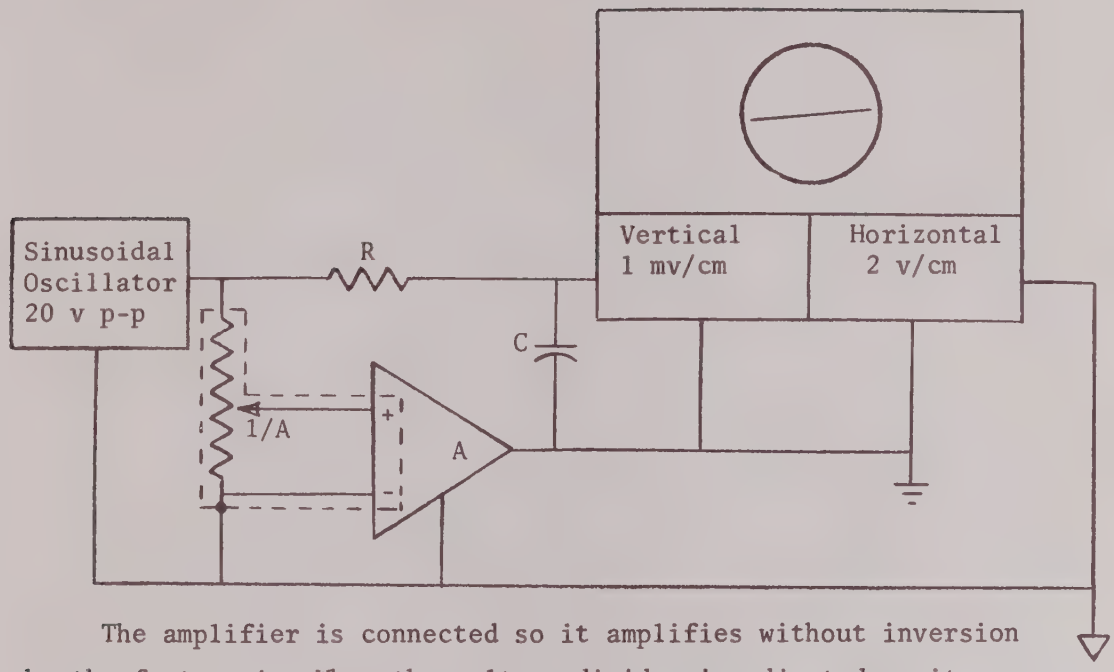
A complete check of CMR consists of a set of measurements at various frequencies under each of three conditions:

(1) Zero resistance in the input leads,
(2) 1K in one of the input leads, and
(3) 1K in the other input lead

Care should be taken to keep the CMV amplitude constant as frequency is varied, except that CMV amplitude should be reduced to 2 volts p-p at 20 kHz and above. In practical applications, common-mode voltage generally is even smaller than this at high frequencies.

Lest there be some pickup from the power line which would confuse the results, it may be advisable to avoid making a CMR measurement exactly at the power frequency. It is helpful to trigger the oscilloscope sweep by the output of the oscillator to obtain a stationary waveform.

Linearity and Gain Accuracy



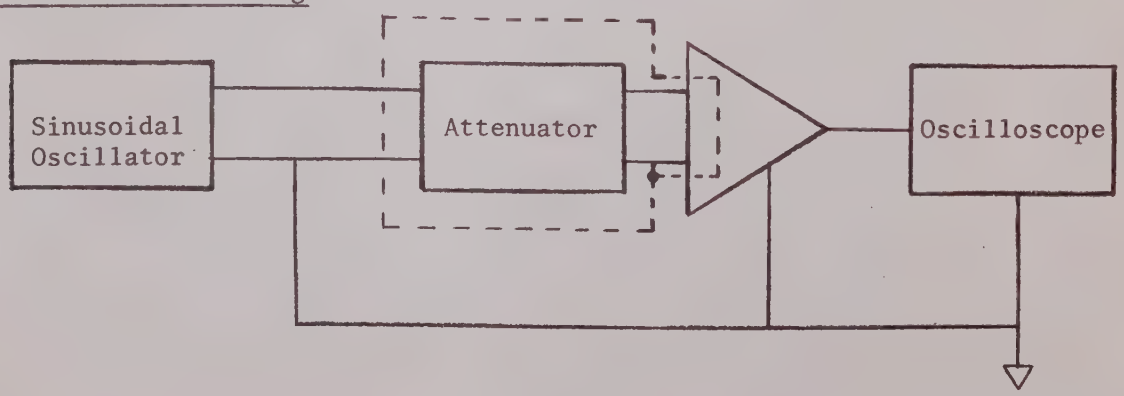
The amplifier is connected so it amplifies without inversion by the factor +A. When the voltage divider is adjusted so its gain is exactly equal to 1/A, perfectly linear operation of the amplifier will produce a straight, horizontal line across the face of the oscilloscope. Inclination of the line at a position other than horizontal signifies deviation of the attenuation ratio from 1/A. For example, if one end of the line is 2 mv above the middle and the other is 2 mv below, attenuation differs from the inverse of gain by 2 mv out of 10 v full scale, or 0.02%. For gain error measurement, the voltage divider must have a certified accuracy at the attenuation setting of interest at least one order of magnitude better than the specified accuracy of the AI amplifier gain. Also, in determining the attenuation factor, the loading effect on the attenuator of the amplifier's 20-megohm input resistance must be taken into account.

Non-linearity in the amplifier is indicated by any curvature of the line across the oscilloscope. The reference line is the best-fit straight line which intersects the oscilloscope trace at its center. Output error due to non-linearity is any displacement of the oscilloscope trace from the reference line, measured vertically in millivolts.

Since non-linearity is vertical deviation from the reference line, this error becomes difficult to measure if the oscilloscope trace is inclined at more than 60^{o} with respect to the horizon. Non-linearity measurement obviously would be impossible if the oscilloscope trace were vertical. Therefore, the input voltage divider should have sufficient resolution to permit adjustment to 1/A with an error no worse than 0.05%. If a step attenuator with decade switches is used, it should have six decades to afford satisfactory resolution at A = 1000.

The results of these tests may be confused by phase shift if the frequency of the test signal is not very low in relation to amplifier bandwidth. Therefore, these tests should be conducted with maximum bandwidth in the amplifier and a very slow sine wave. The ratio of bandwidth to test frequency should be greater than 10,000. Phase shift manifests itself by an elliptical trace instead of a simple line on the oscilloscope. If an RC filter is used to reduce noise on the oscilloscope, its corner frequency must be at least 2.5 times the signal frequency used in making the tests. R may be made about 1 to 5 kilohms without introducing appreciable loading error. As shown in the diagram, the oscilloscope is floating with respect to amplifier ground. It is helpful to synchronize the oscilloscope sweep with the test signal by connecting amplifier ground to the oscilloscope's external trigger. On some oscilloscopes, it may be necessary to attenuate the horizontal input in order to obtain the desired sensitivity.

Bandwidth and Slewing



The oscillator must be capable of generating frequencies at least as high as the bandwidth of the amplifier, which may be as much as 100 kHz. The attenuator is convenient for reducing the input signal as amplifier gain is increased. To obtain a stationary waveform, it is helpful to trigger the oscilloscope sweep by the output of the oscillator.

The -3 db frequency or small-signal bandwidth is determined using a test signal of small enough amplitude to avoid slew limiting which affects high-frequency response to large-amplitude signals. (A separate test to determine slewing characteristics is described later.) At gains of 3 or more, the test signal may be no greater than 10 volts peak-to-peak at the amplifier output. At gains less than 3, the pertinent limitation is the input slewing limit, which dictates that the test signal be no greater than 3.2 volts peak-to-peak at the amplifier input.

The procedure for determining small-signal bandwidth is to increase the signal frequency, keeping constant input amplitude, until the frequency is reached where the signal at the amplifier output is attenuated by 3 db. Since oscillators do not necessarily maintain constant amplitude as the frequency is varied, it is advisable to monitor the amplifier's input as well as its output with the oscilloscope.

The bandwidth indicated on the switch dial is the -3 db frequency for most type AI amplifiers. However, other criteria for bandwidth indication may be adopted on special order, so contract specifications should be consulted in case any anomaly is found in testing bandwidth. With regard to multi-pole filters, it must be kept in mind that the -3 db frequency is not necessarily the same as the natural frequency or asymptotic corner frequency. Also, 4-pole filters are constructed in two, 2-pole sections; and frequency-response characteristics usually are specified only for the final output since this implicitly determines the characteristics

of both sections. The bandwidth of the first, 2-pole section of a 4-pole filter normally may differ from the bandwidth of the final output by a factor of about 1.5.

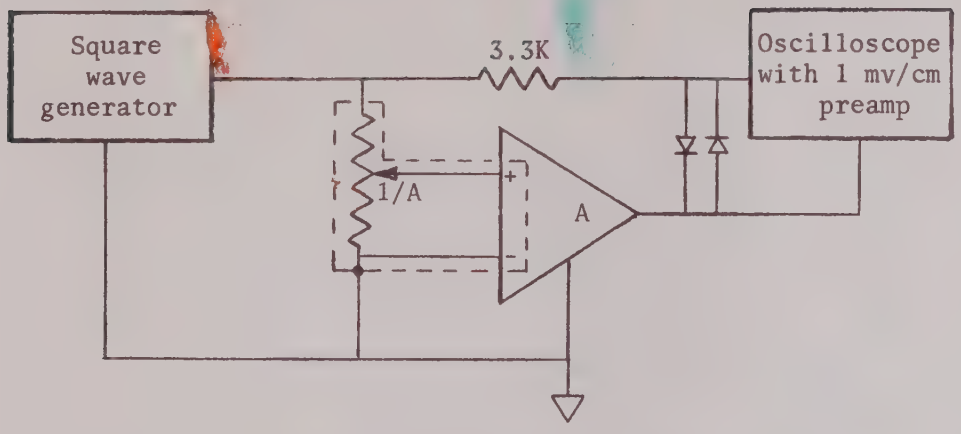
The slewing limit is most easily determined by driving the amplifier to an output of 20 volts peak-to-peak and increasing the signal frequency until the output sine wave begins to distort. The slewing limit then is the maximum slope of the 20-volt, p-p signal at the frequency f (in hertz) on the verge of distortion, which may be calculated

$$\frac{dv}{dt} = 20\pi f \quad \text{volts per second}$$

The slewing limit measured at unity gain is the input slewing limit, and the slewing limit measured at a gain of 3 or greater is the output slewing limit.

Another method of determining the slewing limit is to look for rectification as the amplifier is driven to ± full-scale excursions with a sine wave of increasing frequency. This is accomplished by use of a low-pass filter connected ahead of the oscilloscope to attenuate the test frequency and permit the use of greater sensitivity in the oscilloscope. As the signal frequency is increased beyond the slewing limit, a shift in the DC level may be observed at the amplifier output. At high frequencies, a DC level shift of 10 millivolts may be considered an error of sufficient significance to serve as a criterion of slew-limiting. The frequency at which slew-limiting appears according to this test may be somewhat different from the frequency determined according to the distortion test, but the published slewing specification should be met according to either test method.

Settling Time



The amplifier is connected so it amplifies without inversion by the factor +A. When the voltage divider is adjusted so its gain is exactly equal to 1/A, perfectly linear operation of the amplifier would produce a null across the oscilloscope. Deviation of the attenuation from 1/A will permit a steady-state square wave on the oscilloscope, which is tolerable as long as its amplitude is less than the forward breakdown voltage of the clamp diodes. The oscilloscope should be synchronized by connecting amplifier ground to its external trigger, and adjusted to display the transient error just after the rise (or fall) of the test signal. Notice that the oscilloscope must be floating with respect to amplifier ground.

To meet the settling times stated in the published specifications, the amplifier must have 100 kHz bandwidth capability. For amplifier bandwidths of 16 kHz or less, a properly functioning amplifier will settle according to the theoretical response of the filter employed, so empirical data in this region ordinarily are not needed. At high gain and bandwidth, the noise on the oscilloscope may be larger than the residual settling error which is sought, but any attempt to filter this noise will tend to retard settling.

Diode clamps are used across the input to the oscilloscope to limit the overdrive voltage, but still the oscilloscope

must be able to recover from overdrive (to a residual error less than 1 millivolt) within 5 microseconds. Suitable 'scope preamps are: Hewlett-Packard type 1803A or Tektronix type W.

Performance of the AI is specified for response to a step change of 10 volts referred to the output, so a 10-volt (peak-to-peak) square wave may be used to check this specification. The purpose of the 3.3K resistor is to limit the transient load currents out of the amplifier and the square wave generator.

SPECIAL CHARACTERISTICS
of
SERIAL NUMBER 134

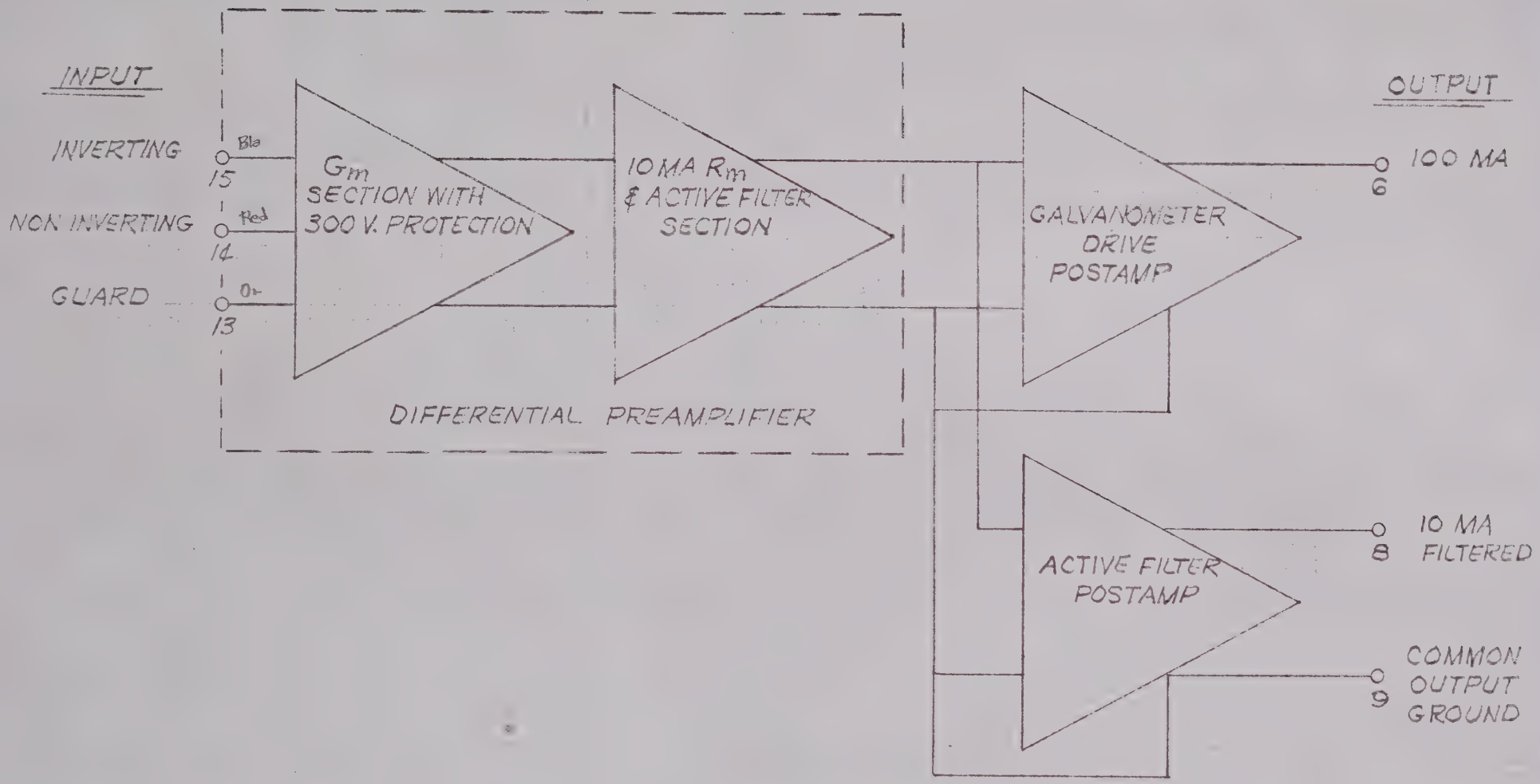
This unit contains a differential preamplifier and provides two outputs via an active-filter postamplifier and a galvanometer-drive postamplifier. The low-level input is protected by fuses against as much as ±300 volts. The DC power supply is an integral part of the package.

The galvanometer-drive postamplifier has a gain of unity and an output capability of 100 ma. The active-filter postamplifier has a DC gain of unity and an output capability of 10 ma.

The calibrated gain of the preamplifier is 1, 3, 10, 30, 100, 300 or 1000 according to switch selection, with gain accuracy ±0.1%. Gain is calibrated at the nominal value when the gain adjustment bypass switch indicates the window where the gain setting is displayed. The gain adjustment bypass switch is the inner knob of the concentric gain control. Fine only or both coarse and fine, continuous gain adjustments become operative when selected by the gain adjustment bypass switch. The range of the coarse gain adjustment is sufficient to obtain gain of any value between the switch steps.

The bandwidth of the preamplifier and the galvanometer-drive postamplifier is approximately 150 khz. The bandwidth of the active-filter postamplifier is 10 Hz, 100 Hz, 1 kHz, 10 kHz, or 100 kHz according to selection by the switch in the lower portion of the front panel. The response characteristic of the active filter is 2-pole Butterworth.

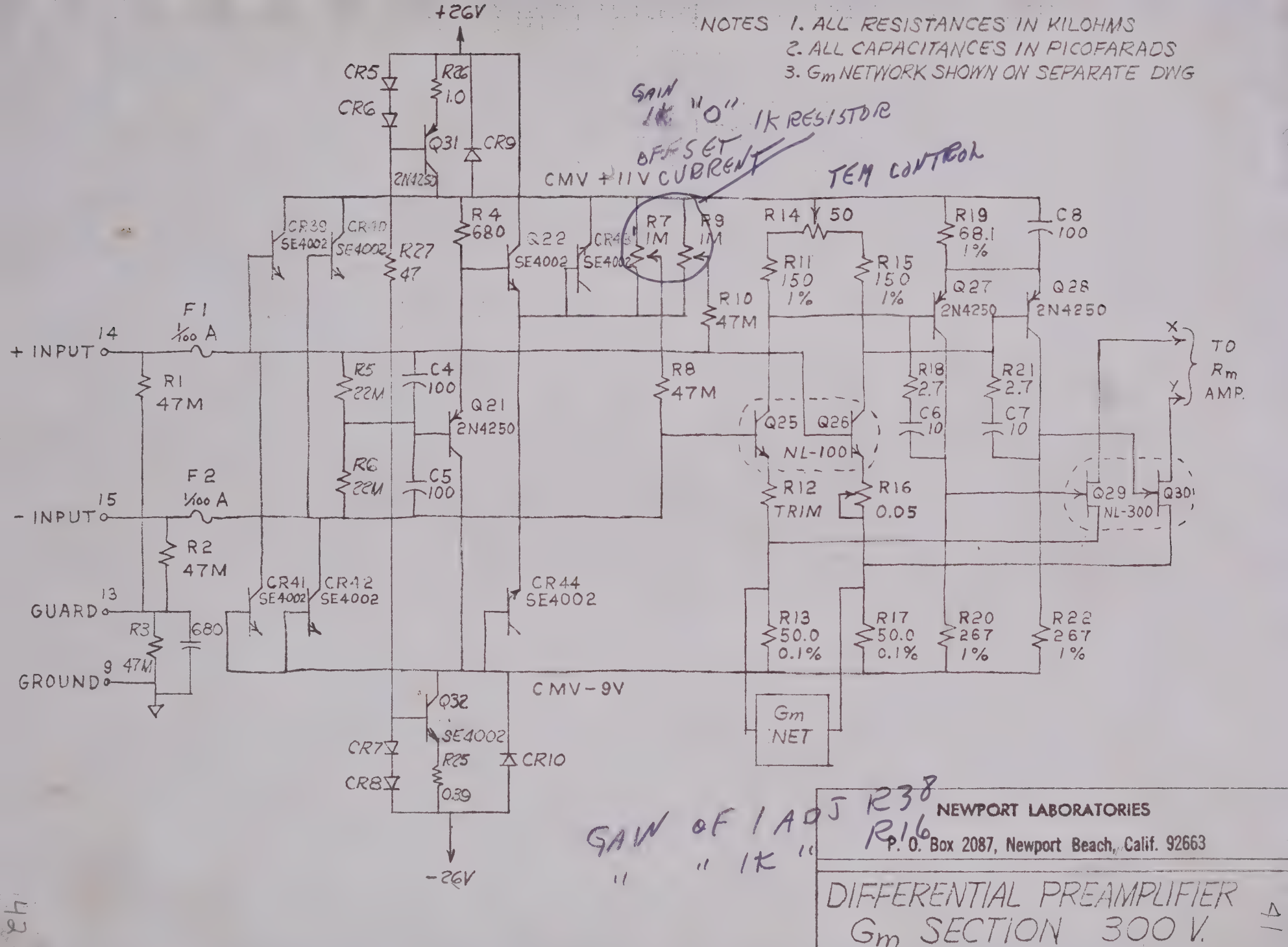
Please refer to Manual page 18, concerning connection of the power transformer shield. In Serial no. 134, the transformer shield is connected to the ground lead of the AC power cord. In case of ground loop trouble, it may be better to employ a 3-to-2 adapter on the AC power plug and connect the transformer shield directly to the amplifier's output ground instead of to AC power ground.



BLOCK DIAGRAM

AI S/N 134

A
3

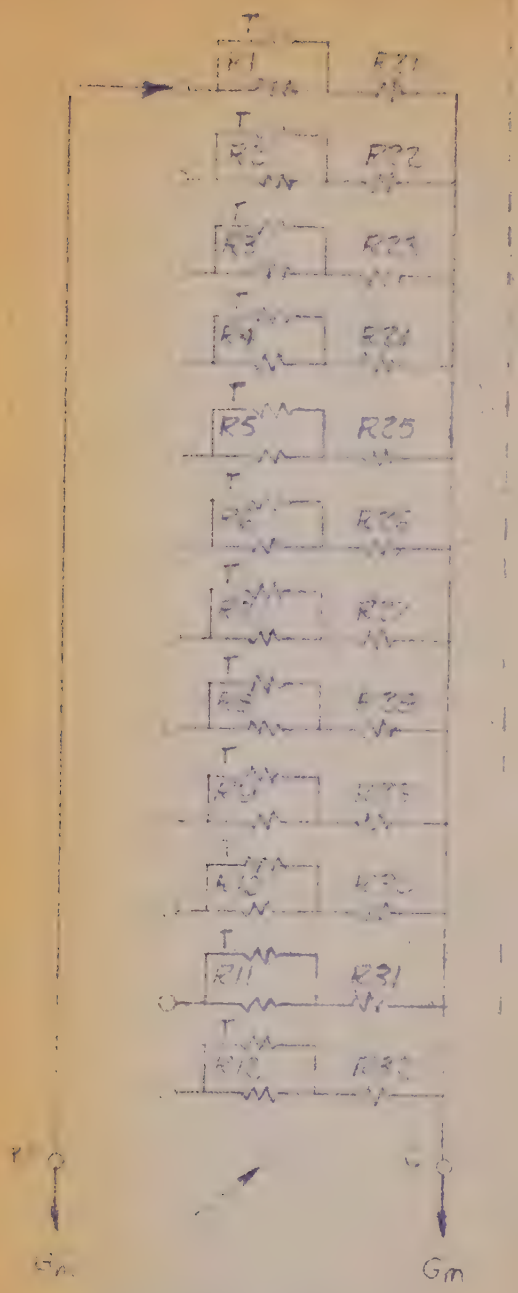

NOTES 1. ALL RESISTANCES IN KILOHMS
2. ALL CAPACITANCES IN PICOFARADS
3. Gm NETWORK SHOWN ON SEPARATE DWG
GAIN IS "0" 1K RESISTOR
OFFSET CURRENT
TEM CONTROL
+26V
CR5
CR6
R26 1.0
Q31 2N4250
CR9
CMV +11V
CR39 SE4002
CR40 SE4002
R27 47
R4 680
Q22 SE4002
CR43 SE4002
R7 1M
R9 1M
R14 Y 50
R11 150 1%
R15 150 1%
R19 68.1 1%
C8 100
Q27 2N4250
Q28 2N4250
R10 47M
F1 1/100 A
14
+ INPUT
R1 47M
R5 22M
C4 100
Q21 2N4250
R8 47M
R18 2.7
C6 10
R21 2.7
C7 10
X
Y
TO Rm AMP.
Q25 Q26
NL-100
R6 22M
C5 100
F2 1/100 A
15
- INPUT
R12 TRIM
R16 0.05
Q29 Q30
NL-300
R2 47M
13
GUARD
CR41 SE4002
CR42 SE4002
CR44 SE4002
R3 47M
680
9
GROUND
R13 50.0 0.1%
R17 50.0 0.1%
R20 267 1%
R22 267 1%
CMV -9V
Gm NET
Q32 SE4002
CR7
CR8
R25 0.39
CR10
-26V
GAIN OF 1 ADJ R238 R16
" " 1K "
NEWPORT LABORATORIES
P. O. Box 2087, Newport Beach, Calif. 92663
DIFFERENTIAL PREAMPLIFIER
Gm SECTION 300 V.
A

circuit number	part description	part no.	manu-facturer	qty.	unit cost	total cost	lot
	BOARD, PRINTED CKT.	NL-	Arnold Ckts.	1			
----------	---CAPACITORS----------	----------	----------	----			
C	680pF, 20% 500V, Cer.		Sprague	1			
C4,5,8	100 pF, 500v, 20%, Cer.		Sprague	3			
C6, 7	10 pF, 500v, 10%, Cer.		Sprague	2			
----------	----DIODES, SILICON----------	----------	----------	----			
CR5,6,7, 8,9,10	50 ma, 30V, glass diffused	D9907	Sylvania	6			
CR39,40 41,42	Very low leakage	SE4002	Fairchild	4			
CR43,44	Zener, 10.6 V.	SE4002	Fairchild	2			
----------	---FUSES----------	----------	----------	----			
F1 & 2	1/100 A, Tron Axial Leads	GFA 1/100	Bussman	2			
----------	-----MECHANICAL PARTS----------	----------	----------	----			
	Box, Shield	NL-1046	Everest	1			
	Cover, Shield	NL-1047	Everest	1			
	Screw, 4-40 x 3/4", PHT Head			1			
	Lockwasher, #4 inside star			1			
	Nut, Hex., 4-40 x ¼"						
----------	----TRANSISTORS----------	----------	----------	----			
Q21,27 28,31	PNP, Low level	2N4250	Fairchild	4			
Q22,32	NPN, Low level	SE4002	Fairchild	2			
Q25, 26	NPN, Twin	NL-100	Fairchild	1			
Q29, 30	Nch Field Effect Twin	NL-300	Un.Carbide	1			
----------	----RESISTORS----------	----------	----------	----	----------	----------	
R25	390Ω, 10%, ¼W, comp.	RC07GF-391K	Speer	1			
R26	1.0K, 10%, ¼W, comp.	RC07GF-102K	Speer	1			
R18, 21	2.7K, 10%, ¼W, comp.	RC07GF-272K	Speer	2			
R27	47K, 10%, ¼W, comp.	RC07GF-473K	Speer	1			
R4	680K, 10%, ¼W, comp.	RC07GF-684K	Speer	1			

dwg. no.	next ass'y.	ass'y. no.	pg. 1 of 2
Newport Laboratories, Inc. Newport Beach, Calif.	originator approved by date	Title: Differential Preamplifier G_m Section, 300V	

circuit number	part description	part no.	manu-facturer	qty.	unit cost	total cost	lot
R5 & 6	22M, 10%, ¼W, comp.	RC07GF-226K	Allen-Brad.	2			
R1,2,3, 8, 10	47M, 10%, ¼W, comp.	RC07GF-476K	Allen-Brad.	5			
R12	Select in test MF	MF5C-D	Electra	1			
R19	68.1K, 1%, ¼W, MF	MF5C-D-6812F	Electra	1			
R20,22	267K, 1%, ¼W, MF	MF5C-D-2673F	Electra	2			
R13, 17	50.0K, 0.1%, 1/8W, WW	7007-50.0K	RCL	2			
R11, 15	150K, 1%, 1/8W, WW	7007-150K	RCL	2			
R16	50Ω, 20%, 3/4W, Var.Cermet	78PR50	Beckman	1			
R14	50K, 20%, 3/4W, Var.Cermet	78PR50K	Beckman	1			
R7 & 9	1M, 30%, ½W, Var.Cermet	62PR1M	Beckman	2			

dwg. no.	next ass'y.	ass'y. no.	pg. 2 of 2
Newport Laboratories, Inc. Newport Beach, Calif.	originator approved by date	Title: Differential Preamplifier G_m Section, 300V	



GAIN SW. MOUNTED PC CARD

STANDARD GAINS	
GAIN	NOMINAL RESISTANCE
1	∞
2	100.0 K
3	50.0 K
5	20.0 K
10	11.1 K
20	5.26 K
30	3.45 K
50	2.04 K
100	1.01 K
200	502 Ω
300	331 Ω
500	200 Ω
1000	100 Ω
2000	50.0

NOTES: 1. ALL GAIN RESISTORS (R1 THRU R12) ARE 0.1% 1/4W WIRE WOUND

2. ALL [illegible] THRU [illegible] TRIM (R21 THRU R30) RESISTORS ARE 10% 1/4W COMPOSITION SELECTED IN TEST.

3. SINGLE GAIN AMPLIFIERS WILL HAVE THE APPROPRIATE GAIN RESISTOR MOUNTED IN THE G_m BLOCK ON THE MOTHER BOARD

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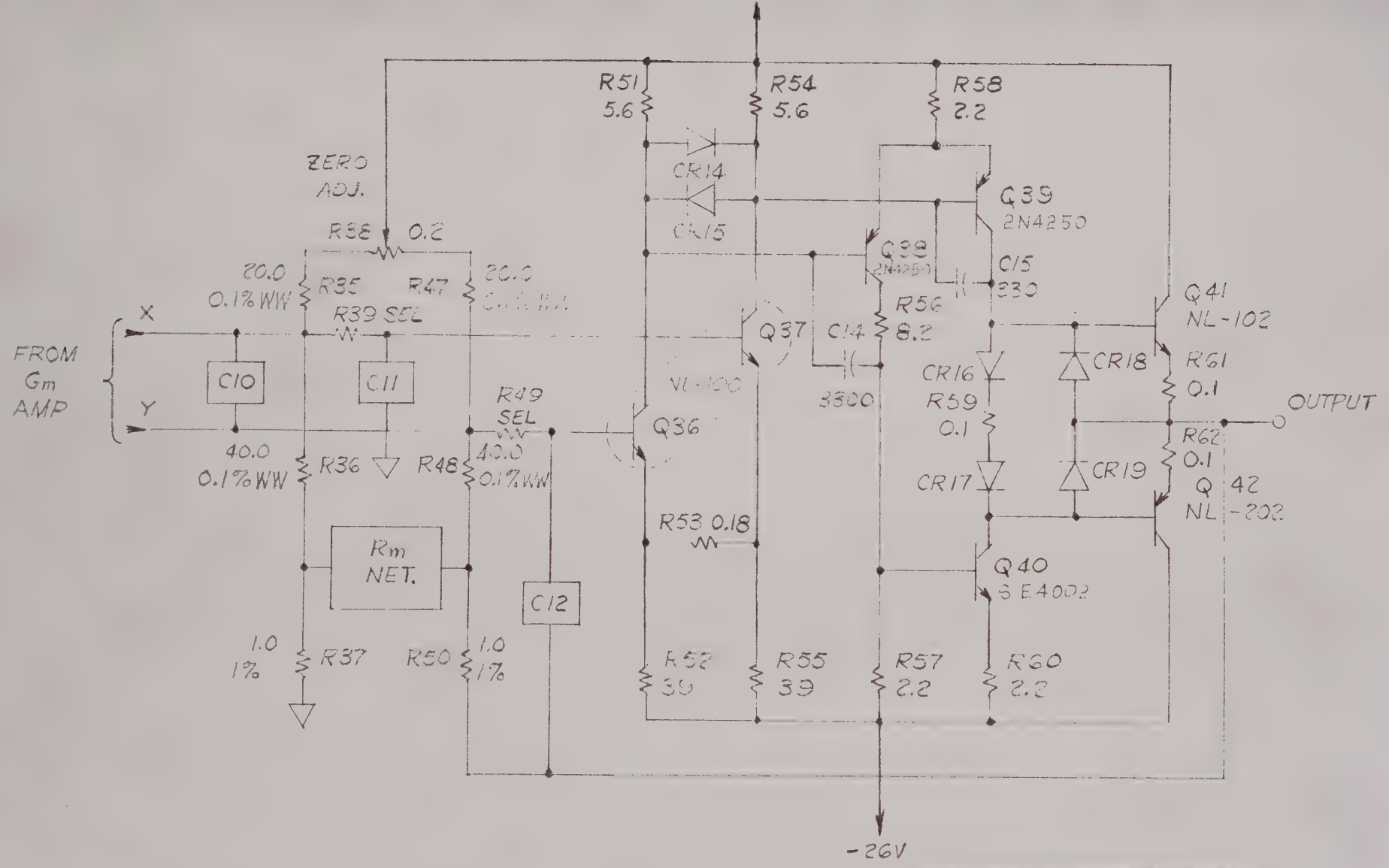
G_m NETWORK



NOTES
1. ALL RESISTANCES IN KILOHMS
2. ALL CAPACITANCES IN PICOFARADS
3. VALUES FOR C10, 11, 12 & R39 & R49 GIVEN IN PREAMPLIFIER FILTER DWG.

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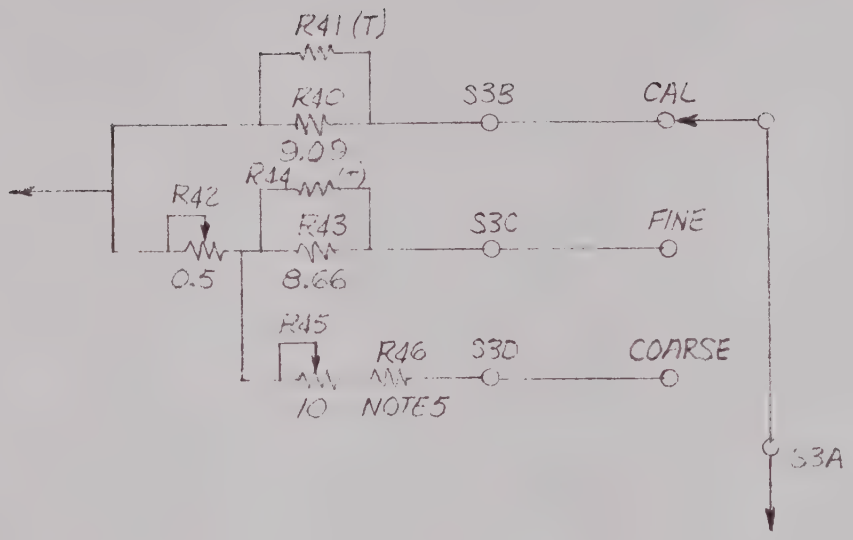
DIFFERENTIAL PREAMPLIFIER 10MA Rm & ACTIVE FILTER SECTION

circuit number	part description	part no.	manu-facturer	qty.	unit cost	total cost	lot
	----------CAPACITORS----------						
C15	330 pF, 20%, 500V, Ceramic		Sprague	1			
C14	3300 pF, 20%, 500V, Ceramic		Sprague	1			
	----------DIODES, SILICON----------						
CR14,15 16,17,							
18 & 19	50 ma, 30V. glass diffused	D9907	Sylvania	6			
	----------TRANSISTORS, SILICON----------						
Q36 & 37	NPN, Twin	NL-100	Fairchild	1			
Q38, 39	PNP, low level	2N4250	Fairchild	2			
Q40	NPN, low level	SE4002	Fairchild	1			
Q51	NPN, Med. level	NL-102	Fairchild	1			
Q52	PNP, Med. level	NL-202	Fairchild	1			
	----------RESISTORS----------						
R61 & 62	100Ω, 10%, ⅓W, comp.	RC07GF-101K	Speer	2			
R53 & 59	180Ω, 10%, ⅓W, comp.	RC07GF-181K	Speer	2			
R57,58, 60	2.2KΩ, 10%, ⅓W, comp.	RC07GF-222K	Speer	3			
R51 & 54	5.6KΩ, 10%, ⅓W, comp.	RC07GF-562K	Speer	2			
R56	10KΩ, 10%, ⅓W, comp.	RC07GF-103K	Speer	1			
R37 &50	1.00KΩ, 1%, ⅓W, MF	MF5C-D-1001F	Electra	2			
R35 &47	20.00KΩ, 0.1%, 1/8W, WW	7007-20.0K	RCL	2			
R36 &48	40.00KΩ, 0.1%, 1/8W, WW	7007-40.0K	RCL	2			
R38	200Ω, 20%, 3/4W, Var.Cermet	78PR200	Beckman	1			

dwg. no.	next ass'y.	ass'y. no.	pg. 1 of 1
Newport Laboratories, Inc. Newport Beach, Calif.	originator approved by date	Title: Differential Preamplifier 10 ma Rm + Active Filter Section	



NOTES
1. ALL RESISTANCES IN KILOHMS
2. R40, R43, & R46 ARE 1% ¼W METAL FILM
3. ALL TRIM RESISTORS (R41 & R44) ARE 10% ¼W COMPOSITION SELECTED IN TEST
4. R42 & R45 ARE ½W VAR CERMET
5.

COARSE GAIN RANGE	R46
1 - 2.5	0.909
1 - 3.3	0.620
1 - 10	0.150

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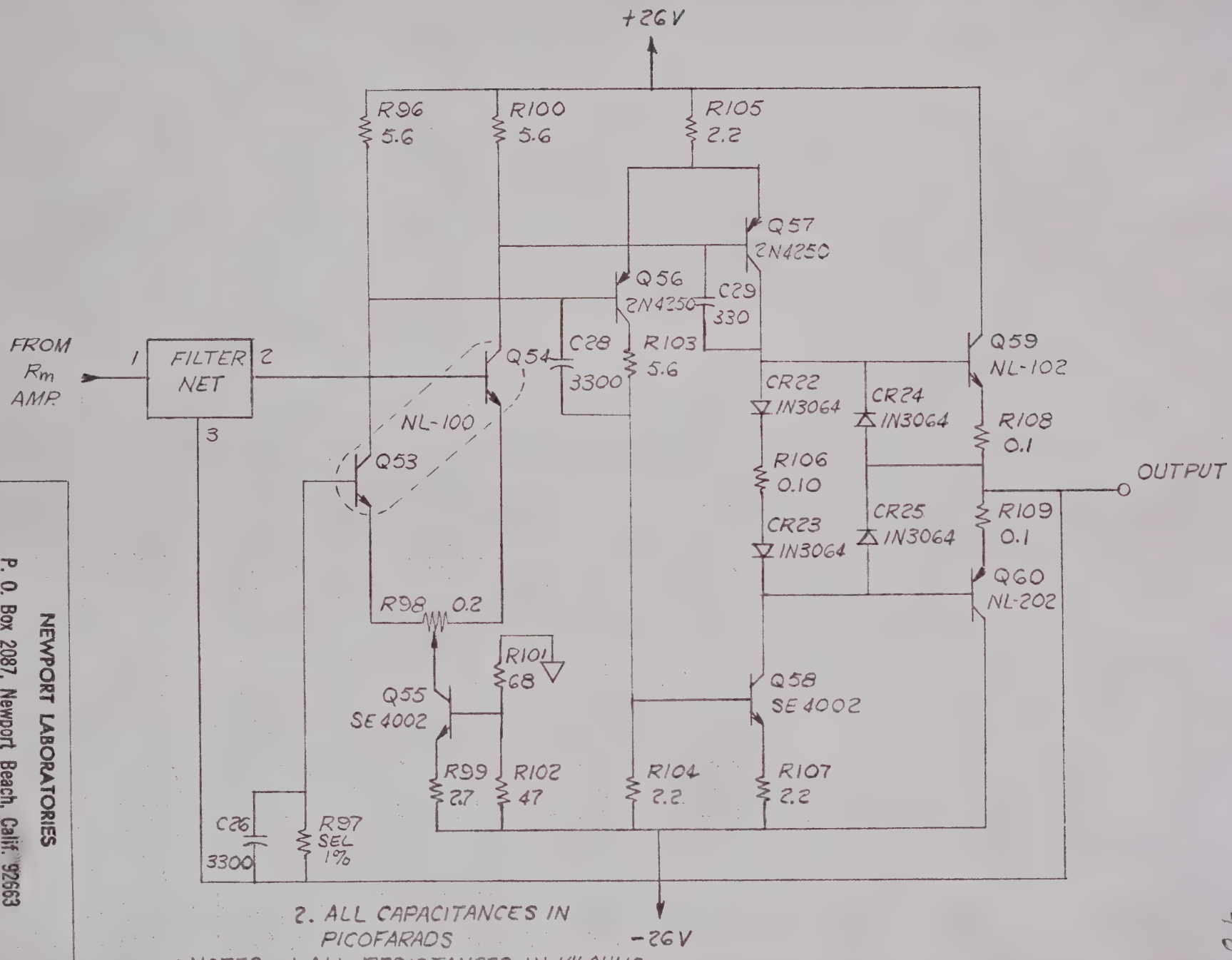
R_m NETWORK 2



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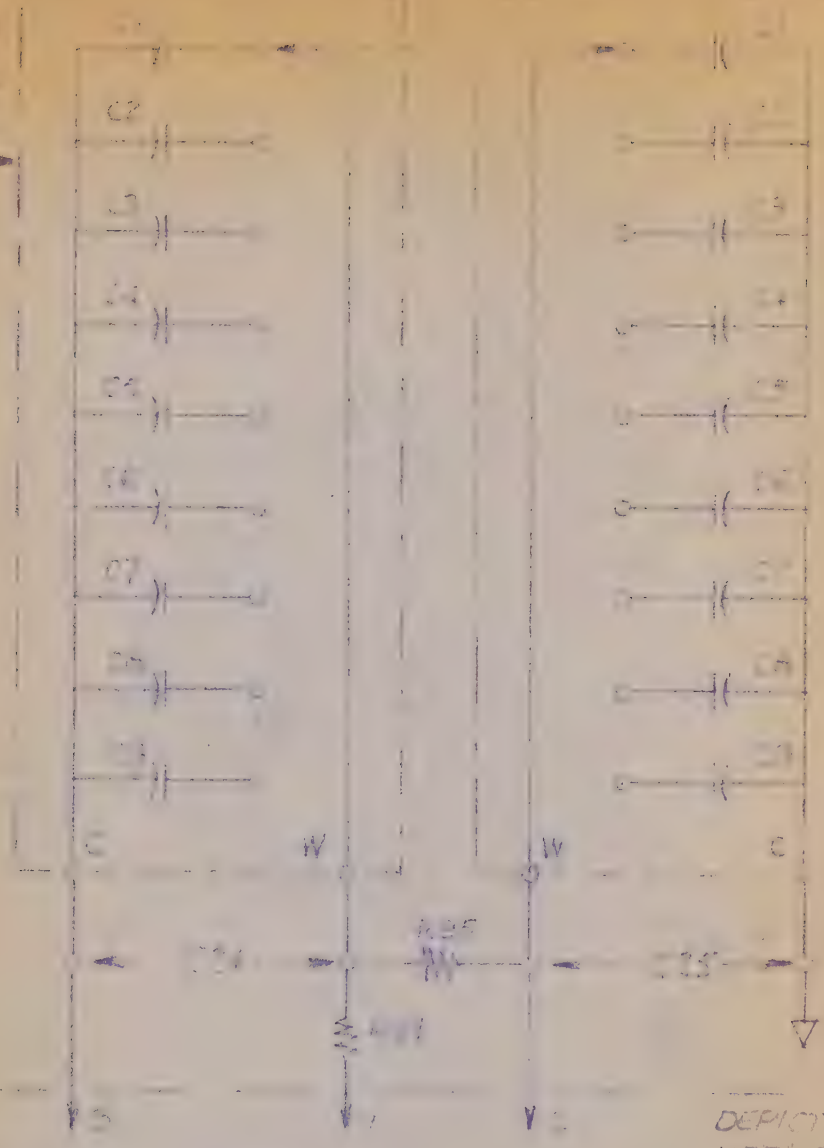
ACTIVE FILTER POSTAMP

circuit number	part description	part no.	manu-facturer	qty.	unit cost	total cost	lot
	-----CAPACITORS-----						
C27, 29	330 pF, 20%,500V, Ceramic		Erie	2			
C26, 28	3300 pF, 20%, 500V, Ceramic		Erie	2			
	-----DIODES, SILICON-----						
CR22, 23 24, 25	50 ma, 30V, glass diffused	D9907	Sylvania	4			
	-----TRANSISTORS, SILICON-----						
Q53, 54	NPN twin	NL-100 or 2N3299	Fairchild	1			
Q55, 58	NPN, low level	SE4002	Fairchild	4			
Q56, 57	PNP, low level	2N4250	Fairchild	2			
Q59	NPN, med. level	NL-102 or 2N3299	Fairchild	1			
Q60	PNP, med. level	NL-202 or 2N3503	Fairchild	1			
	-----RESISTORS-----						
R106,108 109	100Ω, 10%, ¼W. comp.	RC07GF-101K	Speer	3			
R104,109 107	2.2KΩ, 10%, ¼W. comp.	RC07GF-222K	Speer	3			
R99	2.7KΩ, 10%, ¼W. comp.	RC07GF-272K	Speer	1			
R96,100 103	5.6KΩ, 10%, ¼W. comp.	RC07GF-562K	Speer	3			
R102	47KΩ, 10%, ¼W. comp.	RC07GF-473K	Speer	1			
R101	68KΩ, 10%, ¼W. comp.	RC07GF-683K	Speer	1			
R97	Select in test 1%, ¼W, metal film		Electra	1			
R98	200Ω, 30%, ½W, Var. Cermet	62PR200	Beckman	1			

dwg. no.	next ass'y.	ass'y. no.	pg. of
Newport Laboratories, Inc. Newport Beach, Calif.	originator	Title: Active Filter Post-Amp	
	approved by		
	date		



DEPICTED AS "FILTER NET" ON ACTIVE FILTER POSTAMP DWG.

NOTES 1. ALL CAPACITORS ARE 10% MICA, CERAMIC, OR SOLID TANTALUM

2. SINGLE CHANNEL AMPLIFIER WILL HAVE C24 & C25 MOUNTED ON THE MOTHERBOARD

3.

OPTION	K94 (W/ 2MP	FOR W/
BESSEL	17.4 K	
BUTTERWORTH	11.3 K	11.3 K

STANDARD BANDWIDTHS	CAPACITANCE	
	C24	C25
	2.0 uf	1.0 uf
	0.68 uf	0.33 uf
	0.22 uf	0.1 uf
	0.068 uf	0.033 uf
	0.022 uf	0.01 uf
	0.0068 uf	0.0033 uf
	0.0022 uf	0.001 uf
	680 pf	330 pf

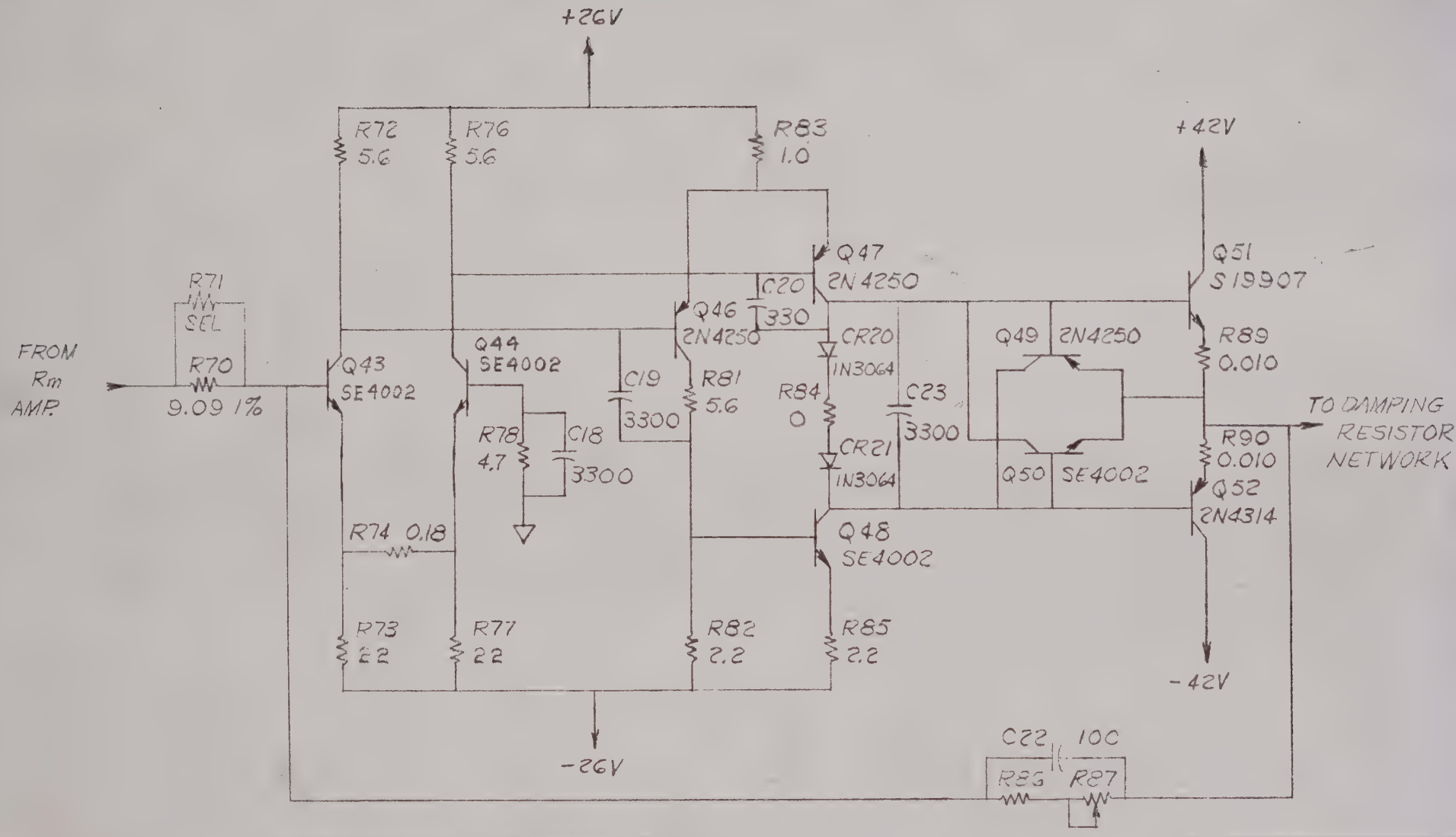
NON-STANDARD BANDWIDTHS		
	22 uf	10.0 uf
	6.8 uf	3.3 uf

NEWPORT LABORATORIES

P. O. BOX [illegible]

FILTER NETWORK
ACTIVE FILTER
[illegible]

NOTES 1. ALL RESISTANCES IN KILOHMS
2. ALL CAPACITANCES IN PICOFARADS



GAIN OPTIONS				
	1	0.1-1	1-10	0.1-10
R86 1% 1/4W MF	8.66	0.909	8.66	0.909
R87 1/2W VAR CERMET	0	10	100	100

NEWPORT LABORATORIES
P. O. Box 2087, Newport Beach, Calif. 92663

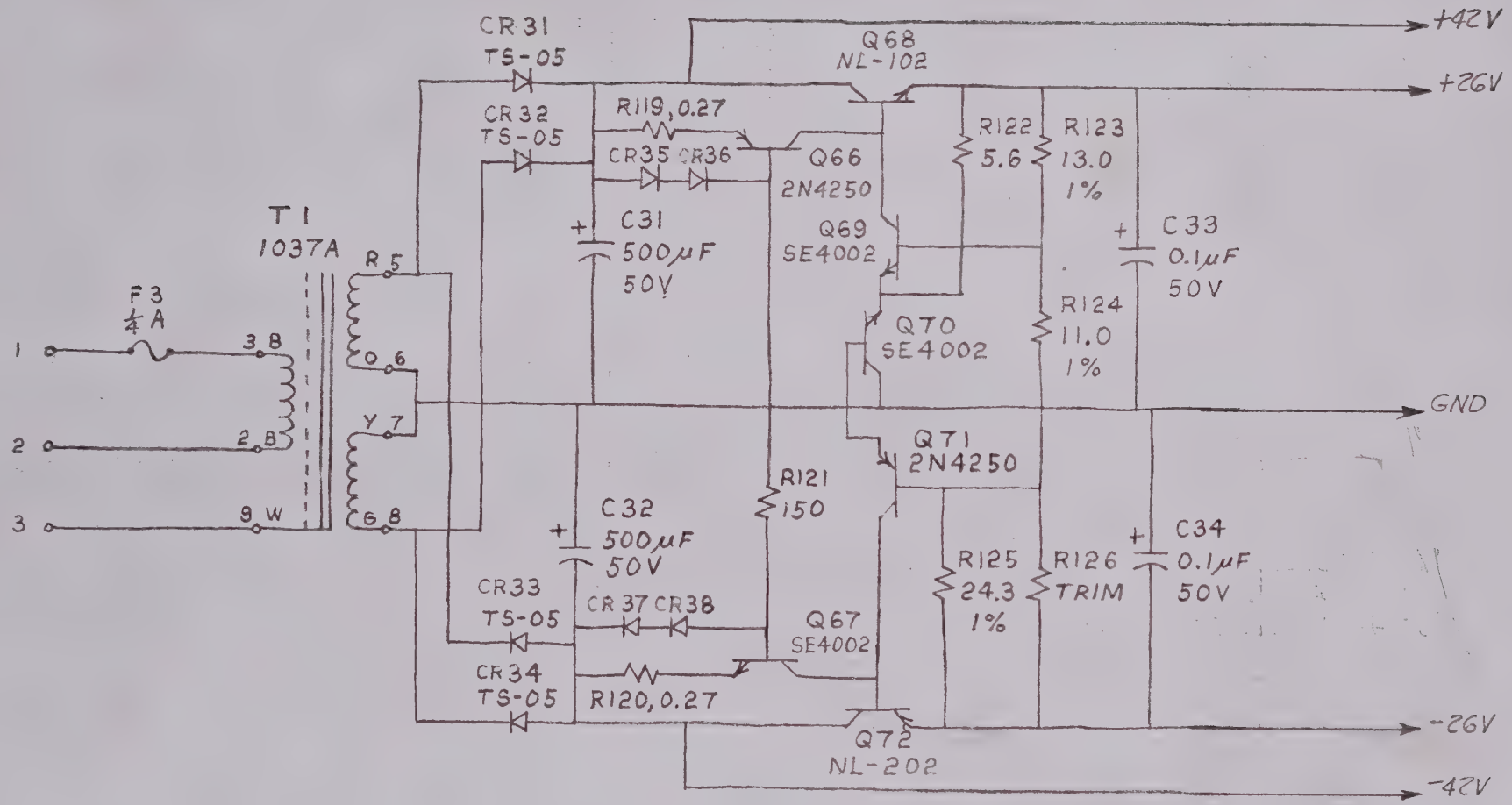
GALVANOMETER DRIVE POSTAMP 1

circuit number	part description	part no.	manu-facturer	qty.	unit cost	total cost	lot
----------	---Capacitors----------	----------	----------	----			
C20	330 pf 1000V, 20% Cer.	5GA-T36	Sprague	1			
C18, 19 23	3300 pf 1000V, 20% Cer.	5GA-D33	Sprague	3			
----------	---Diodes, Silicon----------	----------	----------	----			
DR20,21	50 ma, 30V, glass diffused	D9907	Sylvania	2			
----------	---Misc. Hardware----------	----------	----------	----			
	Dissipators, heat, transistor	LP5B3	IERC	1			
	Mounting hardware for above	A3	IERC	1			
----------	---Potentiometers----------	----------	----------	----			
R87	See gain option chart-Schematic diagram			1			
----------	---Resistors, Composition----------	----------	----------	----			
R89,90	10Ω, 10%, ¼ watt	RC07GF100K		2			
R74	180Ω, 10%, ¼ watt	RC07GF181K		1			
R83	1.0K, 10%, ¼ watt	RC07GF102K		1			
R82, 85	2.2K, 10%, ¼ watt	RC07GF222K		2			
R78	4.7K, 10%, ¼ watt	RC07GF472K		1			
R72, 76 81	5.6K, 10%, ¼ watt	RC07GF562K		3			
R73, 77	22K, 10%, ¼ watt	RC07GF223K		1			
R71	Selected in test, 10%, ¼ watt			1			
----------	---Resistors, Metal Film----------	----------	----------	----			
R70	9.09K, 1%, ¼ W	MF5C-D-9091F	Electra	1			
R86	See gain option chart-schematic diagram			1			
----------	---Transistors----------	----------	----------	----			
Q43,44, 48,50	NPN Low level	SE4002		4			
Q46,47 49	PNP Low level	2N4250		3			
Q51		S19907		1			
Q52		2N4314		1			

dwg. no.	next ass'y.	ass'y. no.	pg. 1 of 2
Newport Laboratories, Inc. Newport Beach, Calif.	originator approved by date	Title: Parts List Galvanometer Drive Postamp 1	

circuit number	part description	part no.	manu-facturer	qty.	unit cost	total cost	lot
	----------Jumpers----------						
R84, R87	If no var gain option, outboard end of 4 to 15,						
	16 to 17, R91, R93, all #3 jumpers, #6, 5A to						
	5B, 5A to 5C, outboard end of R75 to collector of						
	Q45						

dwg. no.	next ass'y.	ass'y. no.	pg. 2 of 2
Newport Laboratories, Inc. Newport Beach, Calif.	originator approved by date	Title: Parts List Galvanometer Drive Postamp 1	



NOTES 1. ALL RESISTANCES IN KILOHMS
2. ALL CAPACITANCES IN PICOFARADS

NEWPORT LABORATORIES
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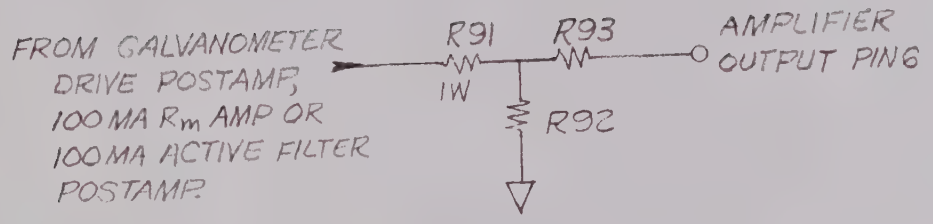
REGULATED POWER SUPPLY



NOTES: 1. TERMINALS FOR R91 & R93 ARE FURNISHED SHORTED, AND R92 IS FURNISHED OPEN UNLESS A GALVANOMETER DAMPING NETWORK IS SPECIFIED BY THE CUSTOMER.

NEWPORT LABORATORIES

P. O. Box 2087, Newport Beach, Calif. 92663

GALVANOMETER DAMPING RESISTOR NETWORK

circuit number	part description	part no.	manu-facturer	qty.	unit cost	total cost	lot
	-----CAPACITORS-----						
C31 & 32	500μF, 50v, +50%-10%, Elect.	2222-023-90011	Amperex	2			
C33 & 34	0.1μF, 50v, 10%, Mylar	75F2R5A104	G.E.	2			
	-----DIODES, SILICON-----						
CR31,32 33, 34	3/4 A, 50v, plastic diffused	TS-05	Diodes,Inc.	4			
CR35,36 37,38	50 mA, 30v, glass diffused	D9907	Sylvania	4			
	-----FUSE-----						
F 3	¼ A, Tron Axial lead	GFA ¼	Bussman	1			
	-----MECHANICAL PARTS-----						
	Dissipator, heat, Transistor	TXBF-032-025B	IERC	2			
	Screw, 4-40 x 1½", Binder Head			2			
	Spacer 3/8"			2			
	Lockwasher, #4 inside star			2			
	Nut, Hex., 4-40 x ¼"			2			
	-----TRANSISTORS-----						
Q66 & 71	PNP, Low level	2N4250	Fairchild	2			
Q67,69, 70	NPN, Low level	SE4002	Fairchild	3			
Q68	NPN, Med. level	NL-102	Fairchild	1			
Q72	PNP, Med. level	NL-202	Fairchild	1			
	-----RESISTORS-----						
R119 & 120	270Ω, ¼W, 10%, comp.	RC07GF-271K	Speer	2			
R121	150KΩ, ¼W, 10%, comp.	RC07GF-154K	Speer	1			
R122	5.6KΩ, ¼W, 10%, comp.	RC07GF-563K	Speer	1			
R123	13.0KΩ, ¼W, 1%, MF	MF5C-D1302F	Electra	1			
R124	11.0KΩ, ¼W, 1%, MF	MF5C-D1102F	Electra	1			
R125	24.3KΩ, ¼W, 1%, MF	MF5C-D-2432F	Electra	1			
	-----TRANSFORMER-----						
T1	Power, step down	NL-1037A	Allkor	1			

dwg. no.	next ass'y.	ass'y. no. 1010-	pg.1 of 1
Newport Laboratories,Inc. Newport Beach, Calif.	originator	Title: Regulated Power Supply	
	approved by		
	date		

Douglas
P. O. 7A-906011
AI Serial No. 134

Pin Assignment

1 - AC

2 - AC

3 - Power Transformer Shield

4 - Not used

5 - Not used — CHANNEL 1

6 - 100 ma output — PLUG B PIN A

7 - Not used

8 - Filtered output — PLUG A PIN A

9 - Output signal common — PLUG A&B PIN B

10 - Not used

11 - Not used

12 - Not used

13 - Guard — XL3-11 / PIN 1

14 - Input non-inverting — PIN 3

15 - Input inverting — PIN 2

NEWPORT LABORATORIES, INC. P.O. BOX 2087 NEWPORT BEACH, CALIFORNIA 92663 TELEPHONE (714) 540-4914